ORIGINAL ARTICLE

Journal of Clinical Microbiology and Infectious Diseases (*JCMID*) 2025, Volume 5, Number 1: 28-33
E-ISSN: 2808-9405

Published By : the Indonesian Society for Clinical Microbiology

Appropriateness of antibiotic use and mortality risk factors in moderate to severe COVID-19 patients admitted to the intensive care unit of Bali Mandara Hospital in 2021

I Wayan Agus Gede Manik Saputra[1*], Ngurah Putu Werda Laksana[2], Luh Gede Dewi Idayanti[3], Made Intan Shantivani[4], Ni Luh Putu Yuliastini[4], I Putu Agus Bayu Pratama[4], Ida Ayu Candrika Widyasari Laksana[5]

[1]Clinical Microbiology Laboratory, Bali Mandara General Hospital, Bali, Indonesia
[2]Medical Staff Group of Intensive Care, Bali Mandara General Hospital, Bali, Indonesia
[3]Medical Staff Unit, Bali Mandara General Hospital, Bali, Indonesia
[4]Antimicrobial Resistance Control Unit, Bali Mandara General Hospital, Bali, Indonesia
[5]Hospital Epidemiology Unit, Bali Mandara General Hospital, Bali, Indonesia

*Corresponding email:
I Wayan Agus Gede Manik Saputra;
Clinical Microbiology Laboratory, Bali Mandara General Hospital, Bali, Indonesia;
gedemaniksaputra@gmail.com

Received: 2024-12-20
Accepted: 2025-03-25
Published: 2025-04-30

ABSTRACT

Introduction: The COVID-19 pandemic has been closely linked to the overuse of antibiotics, particularly in hospitalized patients. Early clinical uncertainty and lack of definitive treatments led to widespread empiric use. This study assessed the appropriateness of antibiotic use and identified mortality risk factors among moderate to severe COVID-19 patients in Bali Mandara Hospital's ICU.

Methods: A retrospective cross-sectional study of 72 moderate to severe COVID-19 patients was conducted from 200 ICU admissions in 2021. Simple random sampling was used. Antibiotic appropriateness was assessed using the Gyssens method. Variables such as age, sex, severity, comorbidities (hypertension, diabetes), and culture results were analyzed using Chi-square tests.

Result: Among 322 antimicrobials, 226 were antibiotics. Gyssens' classification showed 40% appropriate use and 60% inappropriate use, mainly due to lack of indication (Category V). Age over 60, sex, and disease severity were significantly associated with mortality ($p<0.05$). Bacterial co-infection was confirmed in 30.6%, predominantly Enterobacteriaceae.

Conclusion: Antibiotic appropriateness remains low, with substantial overuse. Mortality correlated significantly with age, sex, and disease severity. These findings underscore the need for enhanced antimicrobial stewardship and targeted clinical management in cases of severe COVID-19.

Keywords: COVID-19, Antibiotics, Mortality, Antimicrobial Stewardship, Gyssens.
Cite This Article: Saputra, I.W.A.G.M., Laksana, N.P.W., Idayanti, L.G.D., Shantivani, M.I., Yuliastini, N.L.P., Pratama, I.P.A.B., Laksana, I.A.C.W. 2025. Appropriateness of antibiotic use and mortality risk factors in moderate to severe COVID-19 patients admitted to the intensive care unit of Bali Mandara Hospital in 2021. *Journal of Clinical Microbiology and Infectious Diseases* 5(1): 28-33. DOI: 10.51559/jcmid.v5i1.69

INTRODUCTION

The global health crisis precipitated by the emergence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), which led to the COVID-19 pandemic, has posed unprecedented challenges to public health systems worldwide.[1] In response to the rapid spread and high morbidity of the disease, a range of mitigation strategies were implemented, including the administration of antibiotics to hospitalized patients. Although antibiotics do not directly target viral infections, their extensive use during the pandemic has raised serious concerns about the potential acceleration of antimicrobial resistance (AMR).[2]

Data from the Centers for Disease Control and Prevention (CDC) indicate that during the first year of the pandemic, hospital-onset infections caused by resistant pathogens, as well as associated mortality, increased by 15% or more. Moreover, after years of declining rates, four out of six central healthcare-associated infections (HAIs) showed marked increases in U.S. hospitals in 2020.[3] These trends are particularly concerning, as many of the resistant pathogens responsible for these HAIs exhibit limited susceptibility to available antibiotics and antifungal agents.[4]

COVID-19 predominantly presents respiratory manifestations, which may increase the susceptibility of patients to secondary bacterial infections. In such circumstances, the use of antibiotic therapy may be clinically justified.[5] However, given that antibiotics are inherently ineffective against viral pathogens, their inappropriate or empirical administration, particularly in the absence of definitive evidence of bacterial co-infection, poses a substantial risk of exacerbating the already critical global challenge of AMR.[6]

In clinical practice, antibiotic selection is usually informed by local antimicrobial stewardship policies and prevailing susceptibility patterns. Empirical therapy is often applied in severe cases to cover a broad spectrum of potential pathogens.[7]

However, rising AMR rates have complicated this approach, necessitating a careful balance between achieving adequate coverage and minimizing unnecessary use of broad-spectrum or last-line antibiotics. Both overuse and underuse have been linked to increased mortality.[8,9]

Several factors contributed to the high rate of antibiotic use during the pandemic, especially among patients with severe manifestations of COVID-19: (i) the clinical similarities between SARS-CoV-2 infection and community-acquired bacterial pneumonia; (ii) diagnostic uncertainty and clinician anxiety during the early phases of the pandemic, compounded by the absence of effective antiviral treatments; and (iii) the potential for secondary bacterial, fungal, or opportunistic infections, which are often difficult to distinguish from the primary viral illness.[10,11]

Several studies have reported that a substantial proportion of hospitalized COVID-19 patients, ranging from 70% to 90%, received antibiotics during the early phases of the pandemic, despite the relatively low prevalence of confirmed bacterial co-infections.[12] Intensive care units (ICUs), which treat critically ill patients and frequently involve invasive procedures, are particularly high consumers of antimicrobials.[13] Broad-spectrum antibiotics are frequently used in ICUs to manage severe infections and prevent complications, thereby contributing to the emergence of multidrug-resistant organisms and heightened antibiotic use during the pandemic.[14,15]

Despite these findings, regional patterns of antimicrobial consumption during the COVID-19 pandemic remain inadequately understood. Expanding our knowledge of antibiotic use trends and their implications for resistance development is essential for formulating effective antimicrobial stewardship strategies.[16,17] Therefore, this study aims to evaluate antibiotic consumption within the ICU setting, assess the appropriateness of their use, and identify factors influencing clinical outcomes among moderate to severe COVID-19 patients treated at Bali Mandara Hospital in 2021.

METHODS

Study Design and Population

A retrospective cross-sectional study was conducted at Bali Mandara General Hospital's intensive COVID-19 ward in 2021. Of 200 hospitalized patients, 109 met the inclusion criteria, and 72 were selected via simple random sampling. The inclusion criteria in this study include a confirmed COVID-19 diagnosis (RT-PCR), classified as moderate, severe, or critical, aged ≥18 years, and treated in the intensive COVID-19 ward. The exclusion criteria were incomplete medical records and referred from another hospital. The variables analyzed in this study include mortality and length of stay (LOS) were primary outcomes. LOS was dichotomized at 14 days (mean value). Comorbidities were categorized as hypertension and/or diabetes mellitus. Culture result was defined as any microbiological growth from blood, sputum, or urine collected during ICU stay. The appropriateness of antibiotics was evaluated using the Gyssens method, which classifies prescriptions from Category 0 (rational) to VI (incomplete data)[18], Antimicrobials, involved antibiotics and antivirals, were analyzed in this study. Antibiotics included classes such as fluoroquinolones, cephalosporins, carbapenems, and penicillin-beta-lactamase inhibitor combinations, while antivirals mainly comprised Remdesivir and Favipiravir, consistent with national COVID-19 treatment protocols.

Data Collection and Analysis

Data were extracted from medical records. Descriptive statistics were used to summarize patient demographics, clinical features, and antimicrobial use. Chi-square analysis was used to examine the correlation between demographic characteristics and the clinical status of patients, including clinical outcome and length of stay.

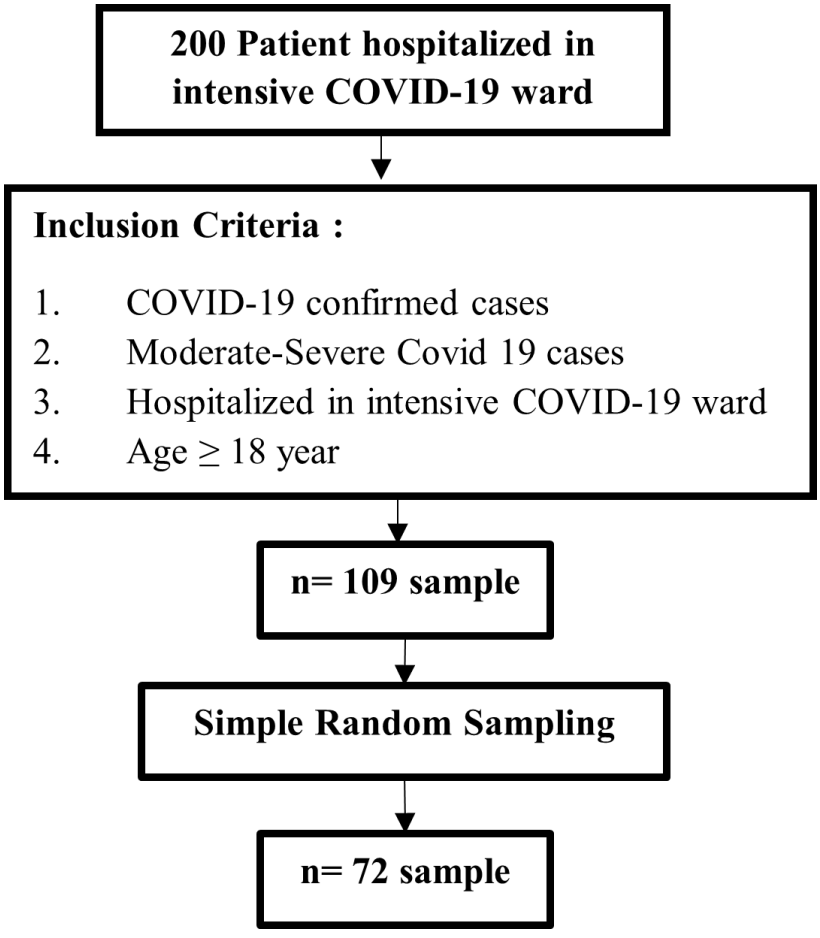

Figure 1. Flowchart of Inclusion Criteria

RESULTS

The demographic and clinical characteristics of the 72 patients included in this study are presented in Table 1. The majority of patients were aged ≤ 60 years (58,3%) and male (62,5%). Comorbidities were observed in 59,72% of patients, with hypertension (27,8%) and diabetes mellitus (31,9%) being the most prevalent. In terms of disease severity, 47,2% of cases were classified as severe and 30,6% as critical. More than half of the patients (52,8%) had a prolonged hospital stay, defined as a length of stay (LOS) greater than 14 days. The 14-day threshold was selected based on previous studies identifying it as a clinically relevant marker of prolonged hospitalization in COVID-19 patients, often associated with increased disease severity, complications, and resource utilization.[19,20] Microbiological culture results were positive in 22 patients, while the remainder showed no microbial growth.

Mortality was observed in 38,9% of cases. Chi-square analysis identified several statistically significant predictors, as shown in Table 2. Patients aged over 60 years exhibited a higher mortality rate (56,7%) compared to younger patients (p = 0,009). Sex also played a significant role; females accounted for 55.6% of deaths, while male patients had a higher rate of recovery, indicating a statistically significant association between sex and clinical outcome (p = 0,025).

Disease severity strongly influenced mortality outcomes. Patients classified as having critical COVID-19 experienced significantly higher mortality compared to those with moderate or severe disease (p = 0,001). Additionally, the presence of comorbidities, specifically hypertension, was significantly associated with prolonged length of stay (LOS) (p = 0,019).

Culture positivity, indicating confirmed bacterial co-infection, was significantly associated with prolonged length of stay (LOS) (p = 0,006), although it did not demonstrate a statistically significant relationship with mortality.

A total of 322 antimicrobial agents were administered during the study period, comprising 226 antibiotics (70,2%) and 96 antivirals (29,8%), as shown in Figure 1. The most frequently prescribed antiviral agents were Remdesivir and Favipiravir, which were in line with national COVID-19 management guidelines. Among the antibiotics, Levofloxacin was the most commonly used, followed by ceftriaxone and meropenem, reflecting the empiric treatment approach frequently adopted in ICU settings where bacterial co-infections were suspected but not always confirmed microbiologically.

The appropriateness of antibiotic use was assessed using the Gyssens method (Table 3). Of the total antibiotic prescriptions, 40% (n = 129) were classified as appropriate (Category 0), indicating adherence to clinical guidelines and proper indications. The remaining 60% (n=193) were considered inappropriate. The most frequent cause of inappropriate use was Category V (n=126), indicating antibiotics were given without a clear clinical indication. Other notable categories included IIIA (n=31), representing prescriptions with a duration that was too short, and IIIB (n=29), where antibiotics were continued longer than necessary.

Table 1. Patient Characteristics and Bacterial Co-Infection in ICU COVID-19 Cases

Variables	n (%)
Age (mean ± SD)	**56,61 ± 15,02**
>60 yo	30 (41,70)
≤60 yo	42 (58,30)
Sex	
Female	27 (37,50)
Male	45 (62,50)
LOS	
>14 day	38 (52,80)
≤14 day	34 (47,20)
Covid-19 Category	
Critical	22 (30,60)
Severe	34 (47,20)
Moderate	16 (22,20)
Type of Comorbid	**43 (59,72)**
Hypertension	20 (27,80)
DM	23 (31,90)
Outcome	
Die	28 (38,90)
Recovery	44 (61,10)
Culture Growth	
Yes	22 (30,60)
No	50 (69,40)

Table 2. Predictive Factors Associated with Clinical Outcomes and Length of Stay in Moderate to Severe COVID-19 Patients

Variable	LOS		p	Outcome		p
	>14 days	≤14 days		Die	Recovery	
Age						
>60 yo	18 (60,00%)	12 (40,00%)	0,300	17 (56,70%)	13 (43,30%)	0,009
≤60 yo	20 (47,60%)	22 (52,40%)		11 (26,20%)	31 (73,80%)	
Sex						
Female	12 (44,40%)	15 (55,60%)	0,273	15 (55,60%)	12 (44,40%)	0,025
Male	26 (57,80%)	19 (42,20%)		13 (28,90%)	32 (71,10%)	
Covid-19 Status						
Critical	13 (59,10%)	9 (40,90%)		19 (86,40%)	3 (13,60%)	
Severe	22 (64,70%)	12 (35,30%)	0,008	9 (26,50%)	25 (73,50%)	0,001
Moderate	3 (18,80%)	13 (81,30 %)		0 (0,00%)	16 (100%)	
Hypertension						
Yes	15 (75,00%)	5 (25,00%)	0,019	8 (40,00%)	12 (60.00%)	0,905
No	23 (44,20%)	29 (55,80%)		20 (38,50%)	32 (61,50%)	
DM						
Yes	12 (52,20%)	11 (47,80%)	0,944	10 (43,50%)	13 (56,50%)	0,584
No	26 (53,10%)	23 (46,90%)		18 (36,70%)	31 (63,30%)	
Culture Results						
Yes	17 (77,30%)	5 (22,70%)	0,006	12 (54,50%)	10 (45,50%)	0,071
No	21 (42,00%)	29 (58,00%)		16 (32,00%)	34 (68,00%)	

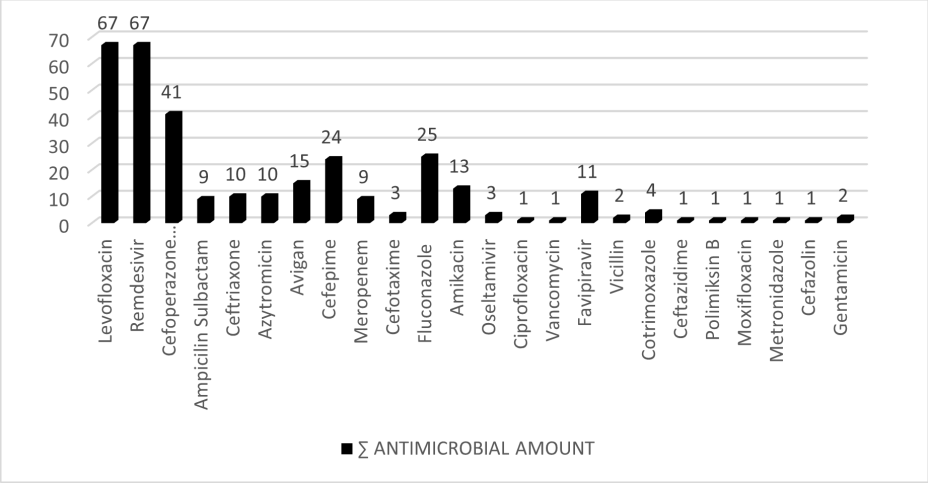

Figure 2. Antimicrobial Usage Profile in Moderate to Severe COVID-19 Patients

Table 3. Appropriateness of Antibiotic Use in ICU COVID-19 Patients Evaluated Using the Gyssens Method

Appropriateness of Antibiotic Use	Gyssens Category		Total n (%)
Appropriate	0	Rational use	129 (40,00)
Inappropriate	III A	Duration too short (n=31)	
	III B	Duration too long (n=29)	
	IV D	Alternative, narrower spectrum (n=3)	193 (60,00)
	V	No Indication (n=126)	
	VI	Incomplete data (n=4)	

These findings suggest that a substantial proportion of antibiotic use was empirical, rather than guided by microbiological confirmation or protocolized evaluation of treatment duration.

DISCUSSION

This study underscores the persistent overuse and frequent inappropriateness of antibiotic use among ICU patients during the COVID-19 pandemic. In line with a Swedish longitudinal study by Karlsson et al. (2023), our findings showed that only 40% of antibiotic prescriptions were considered appropriate, with 60% classified as inappropriate, primarily due to a lack of clear clinical indications (Gyssens Category V). This reflects a global trend of empirical prescribing in the absence of microbiological confirmation, which was also seen in prior meta-analyses and observational studies.[21,22]

Antibiotics, primarily Levofloxacin, ceftriaxone, and meropenem, were administered more frequently than antivirals such as Remdesivir and Favipiravir, which were recommended under Indonesia's COVID-19 treatment protocols.[23] This pattern persisted regardless of patient outcomes, with antibiotics often administered empirically even in the absence of confirmed bacterial co-infections. Despite the high rate of antibiotic use, the actual incidence of bacterial infections among COVID-19 patients remained relatively low at 10,5%.[22] Another study found that despite extensive antibiotic use, culture-confirmed bacterial infections were identified in only 30,6% of patients. [6]

This discrepancy raises concern about the extent of unnecessary antibiotic exposure, underscoring the need for robust diagnostic stewardship.[24] The application of the Gyssens method revealed that 60% of antibiotics were misused, mostly without clinical indication (Category V). This indicates that clinical judgment often favored precautionary or empirical prescribing over evidence-based practices, possibly due to the overlapping clinical presentations of viral and bacterial pneumonia and the limitations of rapid diagnostics in a resource-constrained setting.[25]

In terms of patient outcomes, mortality was significantly associated with key risk factors: age over 60 years, female sex, critical disease classification, and the presence of comorbidities, specifically hypertension and diabetes mellitus. These variables were operationally defined within the study and are supported by other investigations highlighting similar associations. [26,27] Culture positivity also showed a significant association with prolonged length of stay, though it was not independently linked to mortality.[28] These findings are consistent with a broad literature base, including studies that observed increased mortality risks in patients with bacterial co-infections as well as higher ICU needs among patients with comorbidities such as hypertension and diabetes. Notably, these comorbidities may predispose patients to immune dysregulation, leading to more severe disease and extended hospitalizations [29]

Overall, this study illustrates the disconnect between antibiotic prescribing patterns and microbiological evidence of infection. While the majority of patients received antibiotics, only a minority had laboratory-confirmed bacterial infections. This imbalance highlights the need to enhance clinical protocols, improve access to rapid diagnostic testing, and ensure that antimicrobial stewardship programs are actively guiding therapy decisions in real time.[14,30] These findings also validate the need to reform national and institutional treatment protocols to emphasize bacterial confirmation before initiating antibiotics, especially in viral pandemics. Reinforcing stewardship education and auditing antibiotic use regularly in ICU settings may help prevent the downstream consequences of antimicrobial resistance and preserve the efficacy of critical antimicrobial agents [31,32]

This study has several limitations. First, its retrospective design and relatively small sample size limit the generalizability of the findings and restrict the breadth of

variables that could be assessed. Second, not all patients underwent consistent diagnostic testing, including procalcitonin measurement and culture and sensitivity testing, particularly those receiving antibiotics in the 'watch' and 'reserve' categories. This may have affected the ability to verify bacterial infections. In some cases, operational definitions of culture positivity may have included potential contaminants, introducing classification bias. Nonetheless, despite these limitations, the study offers a meaningful snapshot of antimicrobial prescribing practices during a critical phase of the COVID-19 pandemic.

CONCLUSION

Our study contributes to the growing evidence of widespread inappropriate antibiotic use during the COVID-19 pandemic, particularly in ICU settings. Strengthening antimicrobial stewardship through real-time prescribing audits, enhanced diagnostic capabilities, and guideline-based education is crucial. National and institutional policies should prioritize targeted therapy informed by microbiological data, support the availability of rapid diagnostics, and ensure ongoing training for prescribers to mitigate the long-term impact of antimicrobial resistance (AMR).

DISCLOSURE

FUNDING

The authors declared that no financial support or funding was obtained for this study.

CONFLICT OF INTEREST

The authors declare that this research was conducted without any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

AUTHOR CONTRIBUTION

Conceptualization, methodology, and writing original draft preparation conducted by Saputra IWAGM; Formal analysis by Laksana NPW, Saputra IWAGM, Idayanti LGD, Shantivani MI, Yuliastini NLP, Pratama IPAB, Laksana, IACW; validation by Saputra IWAGM; writing, review, and editing by Saputra IWAGM, Laksana NPW; approval of final manuscript by all authors.

ACKNOWLEDGMENTS

We want to acknowledge and give our warmest thanks to all medical staff in Bali Mandara Hospital who were involved in and supported this study. The completion of this project could not have been possible without the participation and assistance of so many people whose names may not all be enumerated.

REFERENCES

1. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus–Infected Pneumonia. New England Journal of Medicine [Internet]. 2020;382(13):1199–207. Available from: https://doi.org/10.1056/NEJMoa2001316
2. Silva ARO, Salgado DR, Lopes LPN, Castanheira D, Emmerick ICM, Lima EC. Increased Use of Antibiotics in the Intensive Care Unit During Coronavirus Disease (COVID-19) Pandemic in a Brazilian Hospital. Front Pharmacol. 2021;12(December):1–11.
3. CDC C for DC and P. COVID-19: U.S. Impact on Antimicrobial Resistance, Special Report 2022. 2022.
4. Witt LS, Howard-Anderson JR, Jacob JT, Gottlieb LB. The impact of COVID-19 on multidrug-resistant organisms causing healthcare-associated infections: A narrative review. JAC Antimicrob Resist [Internet]. 2023;5(1):1–9. Available from: https://doi.org/10.1093/jacamr/dlac130
5. Feldman C, Anderson R. The role of co-infections and secondary infections in patients with COVID-19. Pneumonia [Internet]. 2021;13(1). Available from: https://doi.org/10.1186/s41479-021-00083-w
6. Karlsson PA, Pärssinen J, Danielsson EA, Fatsis-Kavalopoulos N, Frithiof R, Hultström M, et al. Antibiotic use during coronavirus disease 2019 intensive care unit shape multidrug resistance bacteriuria: A Swedish longitudinal prospective study. Front Med (Lausanne) [Internet]. 2023;10(February):1–12. Available from: https://doi.org/10.3389/fmed.2023.1087446
7. Giamarellou H, Galani L, Karavasilis T, Ioannidis K, Karaiskos I. Antimicrobial Stewardship in the Hospital Setting: A Narrative Review. Antibiotics [Internet]. 2023;12(10). Available from: https://doi.org/10.3390/antibiotics12101557
8. Knight GM, Glover RE, McQuaid CF, Olaru ID, Gallandat K, Leclerc QJ, et al. Antimicrobial resistance and covid-19: Intersections and implications. Elife [Internet]. 2021;10:1–27. Available from: https://doi.org/https://doi.org/10.7554/eLife.64139
9. Oliveira M, Antunes W, Mota S, Madureira-Carvalho Á, Dinis-Oliveira RJ, Dias da Silva D. An Overview of the Recent Advances in Antimicrobial Resistance. Microorganisms [Internet]. 2024;12(9):1–50. Available from: https://doi.org/10.3390/microorganisms12091920
10. Bendala Estrada AD, Calderón Parra J, Fernández Carracedo E, Muiño Míguez A, Ramos Martínez A, Muñez Rubio E, et al. Inadequate use of antibiotics in the covid-19 era: effectiveness of antibiotic therapy. BMC Infect Dis [Internet]. 2021;21(1):1–23. Available from: https://doi.org/10.1186/s12879-021-06821-1
11. Lai C cheng, Chen S ying, Ko W chien, Hsueh P ren. Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information. 2020;(January). Available from: https://doi.org/10.1016/j.ijantimicag.2021.106324
12. Langford BJ, So M, Raybardhan S, Leung V, Soucy J paul R, Westwood D, et al. Antibiotic prescribing in patients with COVID-19: rapid review and meta-analysis. Clinical Microbiology and Infection [Internet]. 2020;27(January):520–31. Available from: https://doi.org/10.1016/j.cmi.2020.12.018
13. Ture Z, Güner R, Alp E. Antimicrobial stewardship in the intensive care unit. Journal of Intensive Medicine [Internet]. 2023;3(3):244–53. Available from: https://doi.org/10.1016/j.jointm.2022.10.001
14. Taha I, Abdou Y, Hammad I, Nady O, Hassan G, Farid MF, et al. Utilization of Antibiotics for Hospitalized Patients with Severe Coronavirus Disease 2019 in Al-Madinah Al-Munawara, Saudi Arabia: A Retrospective Study. Infect Drug Resist [Internet]. 2022;15(December):7401–11. Available from: https://doi.org/10.2147/IDR.S386162
15. Russo A, Gavaruzzi F, Ceccarelli G, Borrazzo C, Oliva A, Alessandri F, et al. Multidrug-resistant Acinetobacter baumannii infections in COVID-19 patients hospitalized in intensive care unit. Infection [Internet]. 2022;50(1):83–92. Available from: https://doi.org/10.1007/s15010-021-01643-4
16. Grau S, Echeverria-Esnal D, Gómez-Zorrilla S, Navarrete-Rouco ME, Masclans JR, Espona M, et al. Evolution of antimicrobial consumption during the first wave of covid-19 pandemic. Antibiotics [Internet]. 2021;10(2):1–10. Available from: https://doi.org/ 10.3390/antibiotics10020132
17. Capuozzo M, Zovi A, Langella R, Ottaiano A, Cascella M, Scognamiglio M, et al. Optimizing Antibiotic Use: Addressing Resistance Through Effective Strategies and Health Policies. Antibiotics [Internet]. 2024;13(12):1–14. Available from: https://doi.org/10.3390/antibiotics13121112
18. Van Der Meer JWM, Gyssens IC. Quality of antimicrobial drug prescription in hospital. Clinical Microbiology and Infection [Internet]. 2001;7(SUPPL. 6):12–5. Available from: http://dx.doi.org/10.1046/j.1469-0691.2001.00079.x

19. Alimohamadi Y, Yekta EM, Sepandi M, Sharafoddin M, Arshadi M, Hesari E. Hospital length of stay for COVID-19 patients: a systematic review and meta-analysis. Multidiscip Respir Med [Internet]. 2022;17. Available from: https://doi.org/10.4081/mrm.2022.856
20. Fluck D, Fry CH, Rankin S, Lewis A, Robin J, Rees J, et al. Does the length of stay in hospital affect healthcare outcomes of patients without COVID-19 who were admitted during the pandemic? A retrospective monocentric study. Intern Emerg Med [Internet]. 2022;17(5):1385–93. Available from: https://doi.org/10.1007/s11739-022-02945-7
21. Malik SS, Mundra S. Increasing Consumption of Antibiotics during the COVID-19 Pandemic: Implications for Patient Health and Emerging Antimicrobial Resistance. Antibiotics [Internet]. 2023;12(1). Available from: https://doi.org/10.3390/antibiotics12010045%0AAcademic
22. Cong W, Stuart B, AIhusein N, Liu B, Tang Y, Wang H, et al. Antibiotic Use and Bacterial Infection in COVID-19 Patients in the Second Phase of the SARS-CoV-2 Pandemic: A Scoping Review. Antibiotics [Internet]. 2022;11(8). Available from: https://doi.org/10.3390/antibiotics11080991
23. Burhan E, Susanto AD, Isbaniah F, Nasution SA, Ginanjar E. PEDOMAN TATALAKSANA COVID-19. Jakarta: PDPI, PERKI, PAPDI, PERDATIN, IDAI; 2022.
24. Epstein L, Diekema DJ, Morgan DJ, Fakih MG, Lee F, Gottlieb L, et al. Diagnostic stewardship and the coronavirus disease 2019 (COVID-19) pandemic: Lessons learned for prevention of emerging infectious diseases in acute-care settings. Infect Control Hosp Epidemiol [Internet]. 2024;45(3):277–83. Available from: https://doi.org/10.1017/ice.2023.195
25. Dhesi Z, Enne VI, O'Grady J, Gant V, Livermore DM. Rapid and Point-of-Care Testing in Respiratory Tract Infections: An Antibiotic Guardian? ACS Pharmacol Transl Sci. 2020;3(3):401–17.
26. Patton MJ, Orihuela CJ, Harrod KS, Bhuiyan MAN, Dominic P, Kevil CG, et al. COVID-19 bacteremic co-infection is a major risk factor for mortality, ICU admission, and mechanical ventilation. Crit Care [Internet]. 2023;27(1):1–12. Available from: https://doi.org/10.1186/s13054-023-04312-0
27. Wang IE, Cooper G, Mousa SA. Diagnostic approaches for covid-19 and its associated complications. Diagnostics [Internet]. 2021;11(11). Available from: https://doi.org/10.3390/diagnostics11112071
28. Wu YC, Wong LT, Wu CL, Chao WC. The association between culture positivity and long-term mortality in critically ill surgical patients. J Intensive Care [Internet]. 2021;9(1):1–10. Available from: https://doi.org/10.1186/s40560-021-00576-2
29. Fitero A, Bungau SG, Tit DM, Endres L, Khan SA, Bungau AF, et al. Comorbidities, Associated Diseases, and Risk Assessment in COVID-19 - A Systematic Review. Int J Clin Pract [Internet]. 2022;2022. Available from: https://doi.org/10.1155/2022/1571826
30. Mustafa L, Tolaj I, Baftiu N, Fejza H. Use of antibiotics in COVID-19 ICU patients. J Infect Dev Ctries. 2021;15(4):501–5.
31. Kariyawasam RM, Julien DA, Jelinski DC, Larose SL, Rennert-May E, Conly JM, et al. Antimicrobial resistance (AMR) in COVID-19 patients: a systematic review and meta-analysis (November 2019–June 2021). Antimicrob Resist Infect Control [Internet]. 2022;11(1). Available from: https://doi.org/10.1186/s13756-022-01085-z
32. Chavda VP, Patel AB, Pandya A, Vora LK, Patravale V, Tambuwala ZM, et al. Co-infection associated with SARS-CoV-2 and their management. Future Sci OA [Internet]. 2022;8(9). Available from: https://doi.org/10.2144/fsoa-2022-0011