Section: Microbiology

Original Research Article

STUDY SPECTRUM OF SECONDARY RESPIRATORY TRACT INFECTION IN COVID 19 POSITIVE PATIENTS AT TERTIARY CARE CENTRE OF CENTRAL GUJARAT

Patel, C[1], Kansagara J[2], Patel N[3], Patel JB[4], Pandya Y[5], Bhatt D[6]

[1]*Associate Professor, Department of Microbiology, PramukhSwami Medical College, Bhaikaka University, Karamsad, Gujarat, India.*
[2]*M.Sc. M.T. (M.L.T.), Smt. L P Patel Institute of Medical Laboratory Technology, Bhaikaka University, Karamsad, India.*
[3]*Associate Professor, Department of Microbiology, Banas Medical College & Research institute, Palanpur, Gujarat, India.*
[4]*Assistant Professor of Smt. L P Patel Institute of Medical Laboratory Technology, Bhaikaka University, Karamsad, India.*
[5]*Professor and Head, Department of Microbiology, PramukhSwami Medical College, Bhaikaka University, Karamsad, Gujarat, India.*
[6]*Assistant Professor of Smt. L P Patel Institute of Medical Laboratory Technology, Bhaikaka University, Karamsad, India.*

Received *: 12/07/2025*
Received in revised form *: 19/07/2025*
Accepted *: 31/07/2025*

Corresponding Author:
Dr. Chirag Patel,
Associate Professor, Department of Microbiology, PramukhSwami Medical College, Bhaikaka University, Karamsad, Gujarat, India.
Email: chiragpp@charutarhealth.org

DOI: 10.70034/ijmedph.2025.3.242

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (3); 1310-1315

ABSTRACT

Background: The global outbreak of COVID-19 resulted in over 6.5 million deaths all over the world. Secondary bacterial and fungal infections have been noted in certain patients who recovered from COVID-19 illness. **Objective:** To study the prevalence of bacterial and fungal etiology of respiratory infections in COVID-19 tested positive patients.

Materials & Methods: A cross-sectional, retrospective study was done in the duration of January 2021 to June 2022 among patients who tested COVID-19 positive through RT-PCR at Shree Krishna Hospital. Data was compiled and descriptive statistics was used for analysis.

Results: Total 733 patients tested COVID-19 positive through RT-PCR out of 4868 patients that were admitted to COVID care facility. From these patients a total of 34 respiratory samples were sent for culture and susceptibility test with suspicion of secondary respiratory tract infection. In this study, majority of patients were male (73.5%), and belonged to age group of 61 to 80 years (44.12%). Amongst total samples, Sputum sample were sent the most (58.8%). Result of 17 samples (50%) was deemed insignificant due to contamination of samples with normal pharyngeal flora or non-pathogenic organism. Out of the rest 17 samples, Klebsiella pneumoniae was isolated in 29.41%. Yeast group of fungi (Candida albicans and Candida tropicalis) were isolated only in 11.36% samples.

Conclusion: This study confirms that the incidence of secondary respiratory tract infections in laboratory confirmed patients infected with SARS-CoV-2 is 2.32% (17 out of 733 laboratories confirmed COVID positive patients). A timely diagnosis and management are crucial for improving ultimate outcome of COVID-19 patients with secondary respiratory tract infections.

Keywords: SARS-CoV-2, Secondary respiratory infection, Bacterial and fungal coinfection, antimicrobial susceptibility, Antibiotic resistance, Oxygen therapy, Culture and sensitivity, Retrospective cross-sectional study.

INTRODUCTION

The coronavirus disease-2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) appeared first in Wuhan, China, in December 2019, which rapidly spread to become a pandemic disease.[1,2] The first wave of COVID-19 illness in India occurred between March and April 2020.[3] During the first wave, several adults were affected with COVID-19 and there was rapid spread among the entire population. The second wave of COVID-19 pandemic affected our country 6 months later during September-November 2020.[4] It was observed that each wave had different features and could impact different populations even within the same country based on the immunity of the citizens.

There was rapid spread of this infection during the second wave which was probably due to genetic mutations in the virus.[5]

Most patients with COVID-19 disease may have no or very mild symptoms such as fever and dry cough, but in severe cases, especially in elderly, hypertensive, and diabetic patients, SARS CoV-2 can cause severe acute respiratory syndrome (SARS).[6] Patients with this type of critical illness could show major long-term sequel and frequently show several functional impairments like lung fibrosis, lung damage, impaired lung function, and psychological impairment.[7,8] It was known that viral respiratory infections can predispose individuals to develop secondary bacterial infections, and also observed in the case of COVID-19.[9] Although most patients have received antimicrobial medication & prior published material has shown that COVID-19 co-infection rates with bacteria or fungus stand for fewer than 10%.[10] Thus, our aim of the study was to determine the prevalence & spectrum of secondary respiratory infections in COVID-19 patients. Assess the frequency of antibiotic, steroid, and antifungal use & to analyse associated risks and outcome for respiratory bacterial and fungal secondary infections in COVID-19 hospitalized patients.

MATERIALS AND METHODS

This was a descriptive retrospective cross-sectional study, carried out at Shree Krishna Hospital, Karamsad from January 2021 to June 2022. The study was conducted after the approval of Institutional Ethics Committee of Bhaikaka University, with approval letter no. IEC/BU/139/Faculty/14/94/2023.

Settings & location

Total of 4868 patients were admitted to Covid care facility of Shree Krishna Hospital with clinical suspicion of having Covid 19 infection. Out of these admitted patients, 733 were tested positive for SARS CoV 2 infection with RT-PCR test, oropharyngeal and/or nasopharyngeal swab specimens taken by trained people were be used to make the diagnosis.

Inclusion criteria- All the admitted Covid 19 positive patients of all age groups attending Shree Krishna Hospital, Karamsad, with lab confirmed SARS CoV 2 infection by Rapid antigen detection test or RT-PCR test was included for further analysis.

Exclusion criteria- All the clinically suspected Covid 19 patients, not having laboratory confirmed SARS CoV 2 infection with either of the techniques, of all age groups attending Shree Krishna Hospital & repeated multiple isolation of the same pathogen in the same patient in subsequent samples were excluded from study participant.

Data collection and analysis:

To chase the main objective of the study in those laboratories confirmed Covid 19 cases, the respiratory culture susceptibility reports' data were collected from electronic data of hospital and the secondary infections were identified based on that data. The samples were sent to the microbiology section of Central Diagnostic Laboratory, Shree Krishna Hospital, Bhaikaka University, Karamsad. The samples were processed using standard operating procedure of lab derived from standard references, test books and Clinical Laboratory Standard's Institute (CLSI) guidelines. The cultures showing growth of colonies were identified and antimicrobial susceptibility were performed using Vitek 2 compact (Biomerieux, France) for bacteria and yeast. For moulds the manual culture and conventional identification methods were followed. The isolates were reported by competent signatory authority of lab. All the data was entered and analysed in Microsoft Excel 2010.

RESULTS

During the period of 1st January 2021 to 30th June 2022, a total of 4868 patients were admitted to Shree Krishna Hospital Covid care facility. Out of these patients 733 were found RT-PCR positive for Covid 19. From these patients a total of 34 respiratory samples were sent for culture & antimicrobial susceptibility test with suspicion of secondary respiratory tract infection. Analysis for age wise distribution for male & female patients as shown in figure- 1. Specimen wise distribution of respiratory samples was shown in table- 1.

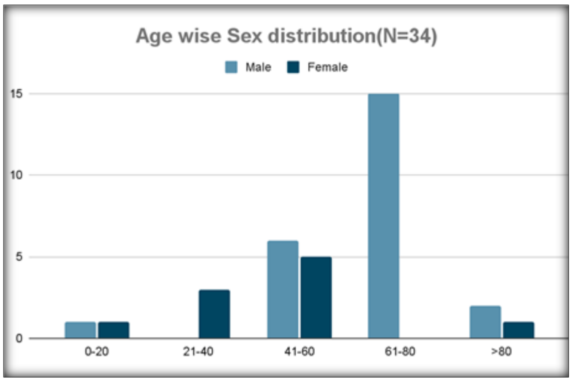

Figure 1: Age wise distribution

Table: 1 Respiratory sample received for culture (n- 34)

Sample	Frequency	Percent
Sputum	20	58.8%
Endotracheal Secretion	7	20.6%
Tracheostomy Secretion	6	17.6%
Nasal Secretion	1	2.9%

Isolated microorganism wise distribution as per the table-2.

Table 2: Spectrum of Culture Positive Isolates

Organism type	Organism	Number (%)
Bacterial isolates (15)	*Acinetobacter haemolyticus*	1 (5.88%)
	Pseudomonas aeruginosa	3 (17.64%)
	Escherichia coli	4 (23.52%)
	Klebsiella pneumoniae	5 (29.41%)
	Achromobacter xylosoxidans	1 (5.88%)
	Serratia marcescens	1 (5.88%)
Fungal isolates (2)	*Candida albicans*	1 (5.88%)
	Candida tropicalis	1 (5.88%)

Ward wise distribution of isolates as shown in table-3.

Table 3: Ward wise prevalence

Admitted to ward/CCU	Frequency	Percent
Privilege Gold	15	44.12
CCU	11	32.35
HDU - A	1	2.94
Medical Ward	1	2.94
MICU	1	2.94
ORTHO WARD	1	2.94
PICU	1	2.94
Deluxe	1	2.94
ENT	1	2.94
GENERAL	1	2.94

The final outcomes of the patients admitted to the hospital reveals diverse as shown in table-4.

Table 4: Final patient outcomes

Final outcome of patient	Frequency	Percent
Discharge with recovery	14	41.2%
DAMA	7	20.6%
Death	3	8.8%

The antibiotics with the highest susceptibility rates in this study were Minocycline and Tigecycline, with rates of 100% and 60% respectively as shown in table-5.

Table 5: Antimicrobial susceptibility of isolates

NO.	ANTIBIOTIC	TOTAL NO.	SUSCEPTIBILITY	
			NUMBER	PERCENTAGE
1	Amikacin	19	8	42.10%
2	Amoxicillin-clavulanate	9	1	11.11%
3	Ampicillin-sulbactam	10	1	10%
4	Ampicillin	4	0	0
5	Cefotaxime	5	2	40%
6	Ceftazidime	14	5	35.71%
7	Ceftriaxone	9	3	33.33%
8	Ciprofloxacin	14	5	35.71%
9	Trimethoprim-sulfamethoxazole (Co-trimoxazole)	12	4	33.33%
10	Gentamicin	15	6	40%
11	Imipenem	9	2	22.22%
12	Minocycline	1	1	100%
13	Nitrofurantoin	1	0	0
14	Tetracycline	9	5	55.56%
15	Cefuroxime	9	1	11.11%
16	Cefuroxime (oral for uncomplicated UTI)	9	1	11.11%
17	Cefoperazone-sulbactam	15	6	40%
18	Levofloxacin	14	6	42.86%
19	Meropenem	10	3	30%
20	Amphotericin-B	2	2	100%
21	Cefepime	15	7	46.67%
22	Colistin	14	4	28.57%
23	Fluconazole	2	2	100%
24	Piperacillin-tazobactam	14	5	35.71%
25	Flucytosine	2	2	100%
26	Ertapenem	8	2	25%
27	Caspofungin	2	2	100%
28	Micafungin	2	2	100%
29	Doripenem	9	2	22.22%
30	Tigecycline	5	3	60%

DISCUSSION

COVID-19 is a respiratory illness caused by the SARS-CoV-2 virus. It has caused a global pandemic since its emergence in late 2019, leading to widespread infections, hospitalizations, and deaths worldwide. Efforts such as vaccination, social distancing, and mask-wearing are crucial in controlling the spread of the virus and mitigating its impact on public health.

SARS-CoV-2 can damage the respiratory tract, increasing the risk of secondary bacterial & viral infections such as *Staphylococcus aureus*, *Haemophilus influenzae*, and *Streptococcus pneumoniae*. Severe COVID-19 patients are at the highest risk for secondary infections, likely due to more extended hospital stays, mechanical ventilation, or immunosuppression. Secondary infections can worsen COVID-19, leading to longer hospital stays and increased mortality. Healthcare providers should monitor patients for signs of secondary infections and provide prompt treatment. Coinfections, where patients are infected with SARS-CoV-2 and influenza, can complicate diagnosis and treatment, so testing for both viruses is essential during flu season, especially for patients with respiratory infection symptoms.

The present study aimed to describe the characteristics of secondary infections and their antimicrobial susceptibility pattern in patients hospitalized with COVID-19. Out of the 34 respiratory culture specimens sent to microbiology lab, a significant portion, specifically 17 (50%) cases, were confirmed to be respiratory infections. The most common secondary bacterial infection was 44.1%.[15]

COVID-19 severity and mortality tend to increase with age, with elderly individuals at higher risk of severe symptoms, hospitalization, and mortality, especially if they have pre-existing health conditions. Children and younger adults are less likely to experience severe symptoms but can still transmit the virus. The virus does not prefer any age group; the risk profile varies.[11] In the present study, the largest group was aged 61-80 (44.12%), followed by 41-60 (32.35%). The age groups 21-40, 0-20, and >80 account for 8.82% each. Older age groups, significantly 61-80 were more affected by COVID-19. In the study by Vijay S *et al.*, the mean age of admitted patients was 53.3 ± 9.36 (SD) years (range 1–97 years).[11] Gender plays a role in COVID-19, with males having a higher risk of severe illness and mortality than females. Biological, behavioural and social factors contribute to this disparity. Hormonal and genetic differences, riskier behaviours, and occupational exposure contribute to higher susceptibility in males. [11,12] Similar to these we found that males 25 (73.5%) were most common than females 9 (26.4) in present study.

During study period, the most prevalent specimen was sputum 20 (58.8%) as compared to others studies.[11,12,13] Among the 15 bacteria isolates, the most prevalent organisms in our study were *Klebsiella pneumoniae* (29.41%), *Escherichia coli* (23.52%) and *Pseudomonas aeruginosa* (17.64%), while *Acinetobacter haemolyticus*, *Achromobacter xylosoxidans*, and *Serratia marcescens* each accounted for 5.88% of the total. In the fungi category, there were two yeast isolates, Candida albicans and Candida tropicalis, each representing 5.88% of the total.

In the study by Khan *et al*., 51 organisms were isolated and identified, with the majority belonging to gram-negative species. Among the gram-negative isolates, *Acinetobacter spp*. was the most prevalent, accounting for 53%, followed by *Klebsiella spp*. (11.8% of the isolates), while *E. coli* and *Proteus mirabilis* represented 9.8% and 5.9%, respectively. *Pseudomonas spp*. comprised a smaller portion, with only 1.9% of the isolates. Regarding gram-positive organisms, MRSA (methicillin-resistant *Staphylococcus aureus*) was the most frequently isolated at 9.8%. *Enterococcus spp*. and Candida spp. each accounted for 3.9% of the isolates.[12]

In the research conducted by Khurana *et al*., they identified positive cultures in 83% (44/53) of the samples, which included endotracheal aspirates and bronchoalveolar lavage (BAL) samples. Among these positive cultures, 12 out of 44 were classified as contaminants, comprising a mixture of Gram-negative/positive organisms or upper respiratory flora. The most frequently isolated pathogens were *Klebsiella pneumoniae* and *Acinetobacter baumannii*.[13]

In the study by Vijay S *et al*, *Klebsiella pneumoniae* was the most frequently isolated bacterium from respiratory samples (35%) and blood samples (29.7%). Other commonly identified bacteria in respiratory samples included *Acinetobacter baumannii* (27%) and *Pseudomonas aeruginosa* (14%). In blood samples, additional isolated pathogens included *Acinetobacter baumannii* (27%), *Enterococcus spp.* (8.7%), and Candida spp. (9.2%). Among urine samples, *Escherichia coli* (27.17%), *Klebsiella pneumoniae* (18.4%), and Candida spp. (18.4%) exhibited the highest rates of isolation.[11]

In our research, most patients, accounting for 91.17% of the total, received antibiotics as part of their treatment. Antifungal medication was administered to 20.59% of the patients. Remdesivir, a specific antiviral medication used to treat certain viral infections, was given to 50% of the patients. Steroids, which are commonly used to reduce inflammation, were prescribed to 44.12% of the patients.

Treatment for COVID-19 involves supportive care, antiviral medications, anti-inflammatory drugs, monoclonal antibodies, immunomodulatory agents, blood-thinning medications, and respiratory support. The specific treatment approach depends on the severity of the illness and individual patient factors. Following medical guidance and tailoring treatment to each patient's needs is essential. In the present study, 64.7% of the patients received oxygen therapy during their treatment as like Ni YN *et al.*[14] This high percentage underscores the importance of oxygen support in managing respiratory distress, a common complication of COVID-19.[5,6]

Oxygen therapy is of utmost importance in managing severe cases of COVID-19, as it plays a vital role in addressing hypoxia, preventing organ damage, easing breathing, and serving as a cornerstone in treating acute respiratory distress syndrome (ARDS). It also acts as a bridge to recovery, supporting patients until their bodies can resume proper oxygenation. Moreover, oxygen therapy facilitates other essential medical interventions, including non-invasive and mechanical ventilation. However, it is crucial to administer this therapy under careful medical supervision, as excessive oxygen levels can also pose potential risks and harm to patients.

The mortality rate in the present study was 8.8. In the study done by Scott H *et al*,[15] the number (%) of deaths was higher in Covid-19 patients than in control patients without Covid-19; 211 (15%) vs 86 (9%), respectively, while in the study done by Garcia Vidal C *et al*,[16] Overall mortality for patients hospitalized with COVID-19 for more than or equals to 48 hours was 9.8%.Khurana *et al.* found that the overall in-hospital mortality rate was 18%, with 209 out of 1,179 patients experiencing fatal outcomes. Among these fatalities, 23.9% of patients had developed secondary infections, which was statistically significant. The primary causes of death were septic shock accompanied by respiratory failure and cardiac arrest.[4,5] Secondary respiratory infections in COVID-19 can contribute to increased mortality rates. Bacterial or viral pneumonia, fungal infections, and coinfections with other coronaviruses can worsen a patient's prognosis. Timely diagnosis and treatment of these infections are essential in reducing mortality risk.

In the present study, the most effective antibiotics, with 100% susceptibility, were minocycline, amphotericin-B, fluconazole, flucytosine, caspofungin, and micafungin. Tigecycline showed a high susceptibility rate of 60%. Other antibiotics with relatively high susceptibility rates include tetracycline (55.56%), cefepime (46.67%), levofloxacin (42.86%), amikacin (42.10%), and cefoperazone-sulbactam (40%). Several antibiotics had moderate susceptibility rates, ranging from 35.71% to 33.33%, such as ceftazidime, ciprofloxacin, piperacillin-tazobactam, trimethoprim-sulfamethoxazole, and ceftriaxone. Meropenem and ertapenem had lower 30% and 25% susceptibility rates, respectively. Ampicillin, ampicillin-sulbactam, amoxicillin-clavulanate, cefuroxime, and cefuroxime (oral for uncomplicated UTI) exhibited the lowest or no susceptibility rates. In the study by Khurana *et al*, the resistance profile of respiratory sample isolates revealed varying levels of resistance to different antimicrobials. Among the samples, 50% showed resistance to amikacin, while amoxicillin/clavulanic acid exhibited resistance in 65.6%. ampicillin, nitrofurantoin, and fluconazole showed no resistance. Resistance to other antibiotics ranged from 9.4% for colistin to 94% for levofloxacin. Notably, ceftazidime, ciprofloxacin, cefepime, and piperacillin/tazobactam displayed significant resistance, with ceftazidime showing resistance in 84.4% of the respiratory samples.54 In the research by Vijay S *et al.*, 47.1% of COVID-19 patients were infected with multidrug-resistant organisms (MDROs). *Klebsiella pneumoniae* isolates exhibited high resistance rates followed by *Acinetobacter baumannii*. Among Enterobacteriaceae, extended-spectrum beta-lactamases (ESBL) were detected in 83.2% (284/341), with 91.7% of *K. pneumoniae* isolates showing resistance to ceftriaxone. Overall, 74.2% (484/652) of Gram-negative bacteria, including *A. baumannii* (92.6%) and *K. pneumoniae* (72.8%) isolates, were resistant to carbapenems. Notably, all *Staphylococcus aureus* and 68% of *Enterococcus spp.* isolates remained susceptible to vancomycin.[11] Sreenath K *et al*., among the 13 patients who underwent respiratory cultures, bacterial pathogens were isolated in 5 patients. Four patients had positive cultures for *Acinetobacter baumannii*, which resisted all tested antibiotics except colistin. Overall, 47.1% of patients had coinfections identified by PCR or culture, with multiple co-detections observed in 24 patients.[17] All these study findings underscore the urgent need for robust antimicrobial stewardship strategies to address the rising prevalence of MDROs and combat resistance in healthcare settings.

CONCLUSION

This study confirms that the incidence of secondary respiratory tract infections in laboratory confirmed patients infected with SARS-CoV-2 is 2.32% (17 out of admitted 733 labs confirmed covid positive patients). Thirty-four respiratory samples received in present study showing 44.1% culture positive and having secondary bacterial infection of respiratory tract. *Klebsiella pneumoniae, Escherichia coli* and *Pseudomonas aeruginosa* were the frequently prevalent organism in present study as secondary respiratory tract infection followed by *Candida albicans* and *Candida tropicalis* as yeast. Oxygen therapy is given in significant number of patients as a part of managing covid infection attributed hypoxia. Antibacterial therapy is also given in significant number of patients suspected for secondary respiratory tract infection. Antimicrobial susceptibility pattern amongst these isolated pathogens from secondary respiratory tract infection was showing a varied degree of susceptibility in different pathogens and antibiotics. A timely diagnosis and appropriate treatment are crucial for reducing mortality and improving ultimate outcome of Covid 19 patients with secondary respiratory tract infections.

Approval of Institutional Ethical Review Board: The study is approved by institutional ethics committee of Bhaikaka University, Karamsad, with approval letter no. IEC/BU/139/Faculty/14/94/2023.

Conflict of interest: There is no conflict of interest for this research for any author and which was declared well in advance in front of institutional ethics committee approval.

Acknowledgment: We express our sincere gratitude to Pramukh swami Medical College, Shree Krishna Hospital, and Bhaikaka University for providing the necessary platform, infrastructure, and institutional support to conduct this research. Their invaluable contribution in terms of resources, clinical data access, and academic encouragement played a pivotal role in the successful completion of this study.

Individual Authors' Contributions: Patel CP* (corresponding author) conceptualized and designed the original study. Patel N, Patel JB, Bhatt D and Kansagara J contributed significantly to data analysis and drafting the manuscript. Pandya Y reviewed the manuscript critically for important intellectual content. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

REFERENCES

1. Babiker A, Myers CW, Hill CE, Guarner J. SARS-CoV-2 testing: trials and tribulations. Am J ClinPathol. 2020;153(6):706–8.
2. Johns Hopkins University Coronavirus Resource Center. Available from: https://coronavirus.jhu.edu/. Accessed 2020 Jan 22.
3. Andrews MA, Areekal B, Rajesh KR, Krishnan J, Suryakala R, Krishnan B, et al. First confirmed case of COVID-19 infection in India: A case report. Indian J Med Res. 2020;151(5):490–2.
4. Ghosh A, Nundy S, Mallick TK. How India is dealing with COVID-19 pandemic. Sens Int. 2020; 1:100021.
5. Grubaugh ND, Hanage WP, Rasmussen AL. Making sense of mutation: what D614G means for the COVID-19 pandemic remains unclear. Cell. 2020;182(4):794–5.
6. Kakamad FH, Mahmood SO, Rahim HM, Abdulla BA, Abdullah HO, Othman S, et al. Post COVID-19 invasive pulmonary Aspergillosis: a case report. Int J Surg Case Rep. 2021; 82:105865.
7. González J, Benítez ID, Carmona P, Santisteve S, Monge A, Moncusí-Moix A, et al. Pulmonary function and radiologic features in survivors of critical COVID-19: a 3-month prospective cohort. Chest. 2021;160(1):187–98.
8. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA. 2020;323(11):1061–9.
9. Rawson TM, Wilson RC, Holmes A. Understanding the role of bacterial and fungal infection in COVID-19. ClinMicrobiol Infect. 2021;27(1):9–11.
10. Rawson TM, Moore LS, Zhu N, Ranganathan N, Skolimowska K, Gilchrist M, et al. Bacterial and fungal coinfection in individuals with coronavirus: a rapid review to support COVID-19 antimicrobial prescribing. Clin Infect Dis. 2020;71(9):2459–68.
11. Vijay S, Bansal N, Rao BK, Veeraraghavan B, Rodrigues C, Wattal C, et al. Secondary infections in hospitalized COVID-19 patients: Indian experience. Infect Drug Resist. 2021; 14:1893–903.
12. Khan S, Nazir A, Bashir H, Amin U. Spectrum of bacterial coinfections of the lower respiratory tract in COVID-19 patients admitted to the ICU of a tertiary care hospital. J Adv Med Med Res. 2021;33(18):99–109.
13. Khurana S, Singh P, Sharad N, Kiro VV, Rastogi N, Lathwal A, et al. Profile of coinfections and secondary infections in COVID-19 patients at a dedicated COVID-19 facility of a tertiary care Indian hospital: implication on antimicrobial resistance. Indian J Med Microbiol. 2021;39(2):147–53.
14. Ni YN, Wang T, Liang BM, Liang ZA. The independent factors associated with oxygen therapy in COVID-19 patients under 65 years old. PLoS One. 2021;16(1): e0245690.
15. Scott H, Zahra A, Fernandes R, Fries BC, Thode HC Jr, Singer AJ. Bacterial infections and death among patients with COVID-19 versus non-COVID-19 patients with pneumonia. Am J Emerg Med. 2022; 52:1–5.
16. Garcia-Vidal C, Sanjuan G, Moreno-García E, Puerta-Alcalde P, Garcia-Pouton N, Chumbita M, et al. Incidence of co-infections and superinfections in hospitalized patients with COVID-19: a retrospective cohort study. ClinMicrobiol Infect. 2021;27(1):83–8.
17. Sreenath K, Batra P, Vinayaraj EV, Bhatia R, SaiKiran KV, Singh V, et al. Coinfections with other respiratory pathogens among patients with COVID-19. MicrobiolSpectr. 2021;9(1): e00163-21.