

A systematic review and meta-analysis of the epidemiology of bacterial and fungal coinfections among patients with SARS-CoV-2 infection: Appendix

Appendix Table 1: PRISMA checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Front page
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	N/A
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1-2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4-5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/A
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3-4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix Table 2-3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5-6

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5-6, 25-26, 34
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6-7

Appendix Table 2: Search strategy MEDLINE via PubMed: search executed on September 2, 2020

Number	Search Term	Hits
1	(((coronaviridae[Mesh:noexp] OR coronavirus[Mesh] OR "Coronavirus Infections"[Mesh] OR Betacoronavirus[Mesh])))	37,027
2	(((Betacoronavirus[tw] OR Beta-coronavirus[tw] OR corona[tw] OR corona'[tw] OR coronaviral[tw] OR coronaviridae[tw] OR coronaviridae[tw] OR coronaviridae[tw] OR coronavirus[tw] OR coronavirus[tw] OR corona virions[tw] OR coronavirologists[tw] OR coronavirology[tw] OR coronaviruses[tw] OR coronavirus[tw] OR coronavirus[tw] OR coronavirus[tw] OR coronavirus'[tw] OR coronavirus's[tw] OR coronavirusscpe[tw] OR coronaviruses[tw] OR coronaviruses[tw] OR coronaviruses'[tw] OR coronavirus like[tw] OR coronaviser[tw] OR coronavirus[tw] OR coronaviruses[tw] OR coronavirus[tw] OR coronavirus[tw] OR COVID[tw])))	70,032
3	(((2019-novel-corona* OR 2019-new-corona* OR novel-corona* OR new-corona* OR 2019-Cov OR 2019-nCov OR nCov OR coronavirus disease-2019 OR SARS2 OR SARS-2 OR SARS-CoV-2 OR sars cORona* OR CORonavirus-2 OR 2019ncov)))	52,746
5	(covid19 OR "covid 19" OR nCoV OR "CoV 2" OR CoV2 OR sarscov2 OR 2019nCoV OR "novel CoV" OR "wuhan virus") OR ((wuhan OR hubei OR huanan) AND ("severe acute respiratory" OR pneumonia) AND (outbreak)) OR "COVID-19" [Supplementary Concept] OR "severe acute respiratory syndrome coronavirus 2" [Supplementary Concept]	48,806
5	(#1 OR #2 OR #3 OR #4)	76,977
6	"Aspergillus"[Mesh] OR "Fungi"[Mesh] OR "Aspergillus fumigatus"[tiab] OR "Aspergillus"[tiab] OR "Bacteria"[Mesh] OR "Staphylococcus"[Mesh] OR "Staphylococcus aureus"[tiab] OR "Enterococcus"[Mesh] OR "Enterococci"[tiab] OR "Pseudomonas aeruginosa"[Mesh] OR "Pseudomonas aeruginosa"[tiab] OR "Acinetobacter"[Mesh] OR "Acinetobacter specie*" [tiab] OR "Streptococcus" [Mesh] OR "Streptococcus pneumoniae"[tiab] OR "Klebsiella"[Mesh] OR "Klebsiella"[tiab] OR "Coinfection"[Mesh] OR "Coinfection*" [tiab] OR "Lung Diseases, Fungal" [Mesh] OR "Fungal Lung Disease" [tiab] OR "Pulmonary Fungal Disease*" [tiab] OR "Fungal Disease*" [tiab] OR "Pulmonary" [tiab] OR "Pulmonary Fungal Infections"[tiab] OR "Pulmonary Fungal Infection" [tiab] OR "Fungal Lung Disease*" [tiab] OR "Pneumonia, Ventilator-Associated" [Mesh] OR "Ventilator-Associated Pneumonia" [tiab] OR "Clinical Pulmonary Infection Score" [tiab] OR "Cross Infection" [Mesh] OR "Infections, Nosocomial" [tiab] OR "Infection, Nosocomial" [tiab] OR "Nosocomial Infection*" [tiab] OR "Enterobacteriaceae" [Mesh] OR "Enterobacteria" [tiab] OR "Coliform Bacilli" [tiab] OR "Sodalis" [tiab] OR "Paracolibactrum" [tiab] OR "Ewingella" [tiab] OR "Leclercia" [tiab] OR "Candida*" [tiab] OR "Monilia*" [tiab] OR "Candida auris" [tiab] OR "Candida utilis" [tiab] OR "Torulopsis utilis" [tiab]	2,663,282
7	#5 AND #6	5,827
8	#7 AND 2019/11/01:2020/08/19 [dp]	3,031
9	#8 AND "English" [la]	2,892

Appendix Table 3: Search strategy EMBASE via OVID: search executed on September 2, 2020

Number	Search Term	Hits
1	'coronaviridae'/exp OR 'coronaviridae' OR 'coronavirus infection'/exp OR 'coronavirus infection' OR 'betacoronavirus'/exp OR 'betacoronavirus'	73,359
2	betacoronavirus:ti,ab,kw OR 'beta coronavirus':ti,ab,kw OR coronavirus*:ti,ab,kw OR covid:ti,ab,kw	56,680
3	#1 OR #2	75,728
4	'coinfection'/exp OR 'coinfection*':ti,ab,kw OR 'superinfection'/exp OR 'Bacterial Infections'/exp OR 'Gram-Negative Bacterial Infections'/exp OR 'Gram-Positive Bacterial Infections'/exp OR 'Pneumonia, Bacterial'/exp OR 'Viral Respiratory Tract Infection'/exp OR 'Bronchitis'/exp OR 'coinfection?':ti,ab,kw OR 'co-infection?':ti,ab,kw OR 'secondary adj3 infection?':ti,ab,kw OR 'ventilator associated pneumonia':ti,ab,kw OR 'ventilator associated infection':ti,ab,kw OR 'clinical pulmonary infection score':ti,ab,kw OR 'nosocomial pneumonia'/exp	1,148,913
5	'aspergillus'/exp OR 'fungi'/exp OR 'aspergillus fumigatus':ti,ab,kw OR 'aspergillus':ti,ab,kw OR 'bacteria'/exp OR 'staphylococcus'/exp OR 'staphylococcus aureus':ti,ab,kw OR 'enterococcus'/exp OR 'enterococci':ti,ab,kw OR 'pseudomonas aeruginosa'/exp OR 'pseudomonas aeruginosa':ti,ab,kw OR 'acinetobacter'/exp OR 'acinetobacter specie*':ti,ab,kw OR 'streptococcus'/exp OR 'streptococcus pneumoniae':ti,ab,kw OR 'klebsiella'/exp OR 'klebsiella':ti,ab,kw OR 'bacteremia'/exp OR 'bacill?emia?':ti,ab,kw OR 'candida':ti,ab,kw OR 'candida'/exp	2,286,414
6	#4 OR #5	2,967,155
7	#3 AND #6	6,108
8	'animals'/exp NOT ('animals'/exp AND 'humans'/exp)	5,485,924
9	#7 NOT #8	5,236
10	#9 AND [11-1-2019]/sd	2,404
12	#10 AND [english]/lim	2,351

Appendix Table 4: Excluded primary studies with reasons for exclusion

No.	PMID or Other Identifier	First Author Last Name	Title	Journal	Reason for Exclusion
1	32725054	Agrifoglio	COVID-19 and fungal co-infections: We must keep them in mind	J Mycol Med	Narrative Review
2	32835340	Alanio	Prevalence of putative invasive pulmonary aspergillosis in critically ill patients with COVID-19	Lancet Respir Med	Single group N<50
3	32445626	Amaral	Lung cavitation in COVID-19: co-infection complication or rare evolution?	Einstein (Sao Paulo, Brazil)	Case report or Case Series
4	32776930	Antunes	Will cases of leprosy reaction increase with covid-19 infection?	PLoS Neglected Tropical Diseases	Narrative Review
5	32173883	Barrasa	SARS-CoV-2 in Spanish Intensive Care Units: Early experience with 15-day survival in Vitoria	Anaesthesia Critical Care and Pain Medicine	Single group N<50
6	32339350	Begley	Assessing the risk of nosocomial infection posed by COVID-19 tracheal intubation: the first intubate COVID results	Anaesthesia	Narrative Review
7	32502643	Bengochea	SARS-CoV-2, bacterial co-infections, and AMR: the deadly trio in COVID-19?	EMBO Mol Med	Narrative Review
8	32659385	Beovic	Antibiotic use in patients with COVID-19: a 'snapshot' Infectious Diseases International Research Initiative (ID-IRI) survey	J Antimicrob Chemother	Not COVID-19 patients
9	32779609	Brill	COVID-19: A retrospective cohort study with focus on the over-80s and hospital-onset disease	BMC Medicine	Outcome not of interest
10	32369240	Bruno	COVID-19-associated pulmonary aspergillosis: adding insult to injury	Lancet Microbe	Case report or Case Series
11	32586667	Buckner	Clinical Features and Outcomes of 105 Hospitalized patients with COVID-19 in Seattle, Washington	Clin Infect Dis	Does not address RQ1-2
12	32482367	Calcagno	Co-infection with other respiratory pathogens in COVID-19 patients	Clin Microbiol Infect	Single group N<50
13	32490853	Carter	Nosocomial COVID-19 infection: examining the risk of mortality. The COPE-Nosocomial Study (COVID in Older PEople)	J Hosp Infect	Does not address RQ1-2
14	32822882	Castillo	Rates of coinfection with other respiratory pathogens in patients positive for coronavirus disease 2019 (COVID-19)	J Am Coll Emerg Physicians Open	Does not address RQ1-2
15	32506122	Cen	Risk factors for disease progression in patients with mild to moderate coronavirus disease 2019-a multi-centre observational study	Clin Microbiol Infect	Outcome not of interest
16	32742893	Chan	Collateral benefits on other respiratory infections during fighting COVID-19	Med Clin (Barc)	Does not address RQ1-2
17	32562422	Chang	Underestimation of co-infections in COVID-19 due to non-discriminatory use of antibiotics	J Infect	Narrative Review
18	32653618	de Macedo	COVID-19 and acute juvenile paracoccidioidomycosis coinfection	PLoS Negl Trop Dis	Case report or Case Series
19	32662120	Fan	COVID-19 and mycoplasma pneumoniae coinfection	Am J Hematol	Case report or Case Series
20	32669467	Feld	Ferritin levels in patients with COVID-19: A poor predictor of mortality and hemophagocytic lymphohistiocytosis	International Journal of Laboratory Hematology	Single group N<50
21	32444880	Fu	Secondary Bacterial Infections in Critical Ill Patients With Coronavirus Disease 2019	Open Forum Infect Dis	Single group N<50
22	32702463	Gangneux	Is the COVID-19 Pandemic a Good Time to Include Aspergillus Molecular Detection to Categorize Aspergillosis in ICU Patients? A Monocentric Experience	J Fungi (Basel)	Single group N<50
23	32838387	Garassino	COVID-19 in patients with thoracic malignancies (TERAVOLT): first results of an international, registry-based, cohort study	Lancet Oncol	Outcome not of interest

24	32616098	Garcia-Vidal	Incidence of co-infections and superinfections in hospitalised patients with COVID-19: a retrospective cohort study	Clin Microbiol Infect	Outcome not of interest
25	32803216	Guner	COVID-19 experience of the major pandemic response center in the capital: Results of the pandemic's first month in Turkey	Turk J Med Sci	Single group N<50
26	32170625	Han	Procalcitonin for patient stratification and identification of bacterial co-infection in COVID-19	Clin Med (Lond)	Narrative Review
27	32790918	Hazra	Coinfections with SARS-CoV-2 and other respiratory pathogens	Infect Control Hosp Epidemiol	Does not address RQ1-2
28	32381426	Hinks	A multi-centre open-label two-arm randomised superiority clinical trial of azithromycin versus usual care in ambulatory COVID-19: study protocol for the ATOMIC2 trial	Trials	Outcome not of interest
29	32470606	Huang	Epidemiological, virological and serological features of COVID-19 cases in people living with HIV in Wuhan City: A population-based cohort study	Clin Infect Dis	Does not address RQ1-2
30	32352574	Hughes	Bacterial and fungal coinfection among hospitalized patients with COVID-19: a retrospective cohort study in a UK secondary-care setting	Clin Microbiol Infect	Outcome not of interest
31	32562797	Kim	Rates of Co-infection Between SARS-CoV-2 and Other Respiratory Pathogens	Jama	Outcome not of interest
32	32447256	Koehler	COVID-19 associated pulmonary aspergillosis	Mycoses	Case report or Case Series
33	32622953	Kreitmann	Early bacterial co-infection in ARDS related to COVID-19	Intensive Care Med	Single group N<50
34	32530499	Lahmer	Invasive pulmonary aspergillosis in severe coronavirus disease 2019 pneumonia	Clin Microbiol Infect	Case report or Case Series
35	32651137	Lai	Co-infections among patients with COVID-19: The need for combination therapy with non-anti-SARS-CoV-2 agents?	J Microbiol Immunol Infect	Narrative Review
36	32678816	Lamoth	Incidence of invasive pulmonary aspergillosis among critically ill COVID-19 patients	Clin Microbiol Infect	Case report or Case Series
37	32700320	Langford	Bacterial co-infection and secondary infection in patients with COVID-19: a living rapid review and meta-analysis	Clin Microbiol Infect	Narrative Review
38	32453917	Lei	Fungal antigenemia in patients with severe Coronavirus disease 2019 (COVID-19): The facts and challenges	J Microbiol Immunol Infect	Does not address RQ1-2
39	32628960	Li	Coinfection with SARS-CoV-2 and other respiratory pathogens in patients with COVID-19 in Guangzhou, China	J Med Virol	Outcome not of interest
40	32414743	Li	Coinfection with SARS-CoV-2 and other respiratory pathogens in COVID-19 patients in Guangzhou, China	Journal of Medical Virology	Single group enrolled N<50
41	32482366	Li	Clinical features and short-term outcomes of elderly patients with COVID-19	Int J Infect Dis	Outcome not of interest
42	32711058	Lima	Ventilator-associated pneumonia (VAP) caused by carbapenem-resistant Acinetobacter baumannii in patients with COVID-19: Two problems, one solution?	Med Hypotheses	Narrative Review
43	32758905	Lin	Co-infections of SARS-CoV-2 with multiple common respiratory pathogens in infected patients	Sci China Life Sci	Does not address RQ1-2
44	32474891	Liu	Clinical characteristics of foreign-imported COVID-19 cases in Shanghai, China	Emerging Microbes and Infections	Single group N<50
45	32737746	Liu	Epidemiological and Clinical Characteristics of Patients With Coronavirus Disease-2019 in Shiyuan City, China	Front Cell Infect Microbiol	Outcome not of interest
46	32754626	Luong-Nguyen	Nosocomial infection with SARS-Cov-2 within Departments of Digestive Surgery	J Visc Surg	Does not address RQ1-2
47	32687390	Ma	Clinical characteristics of critically ill patients co-infected with SARS-CoV-2 and the influenza virus in Wuhan, China	Int J Infect Dis	Does not address RQ1-2
48	32835328	McRae	Clinical decision support tool and rapid point-of-care platform for determining disease severity in patients with COVID-19	Lab Chip	Does not address RQ1-2

49	32393593	Morena	Off-label use of tocilizumab for the treatment of SARS-CoV-2 pneumonia in Milan, Italy	European Journal of Internal Medicine	Outcome not of interest
50	32766706	Nowak	Co-infection in SARS-CoV-2 infected Patients: Where Are Influenza Virus and Rhinovirus/Enterovirus?	J Med Virol	Does not address RQ1-2
51	32654303	Palmieri	Clinical Characteristics of Hospitalized Individuals Dying with COVID-19 by Age Group in Italy	The journals of gerontology. Series A, Biological sciences and medical sciences	Does not address RQ1-2
52	32743594	Porretta	Increased Risk of Acquisition of New Delhi Metallo-Beta-Lactamase-Producing Carbapenem-Resistant Enterobacterales (NDM-CRE) among a Cohort of COVID-19 Patients in a Teaching Hospital in Tuscany, Italy	Pathogens	Outcome not of interest
53	32586323	Povoa	COVID-19: An Alert to Ventilator-Associated Bacterial Pneumonia	Infect Dis Ther	Narrative Review
54	32526275	Rajaraman	Iteratively Pruned Deep Learning Ensembles for COVID-19 Detection in Chest X-rays	IEEE Access	Does not address RQ1-2
55	32807209	Regazzoni	Glucocorticoid-Induced Bacterial Endocarditis in COVID-19 Pneumonia Something to Be Concerned About?	Circulation journal : official journal of the Japanese Circulation Society	Case report or Case Series
56	32462695	Rickman	Nosocomial transmission of COVID-19: a retrospective study of 66 hospital-acquired cases in a London teaching hospital	Clin Infect Dis	Does not address RQ1-2
57	32515651	Roberts	COVID-19 in solid organ transplant recipients: Dynamics of disease progression and inflammatory markers in ICU and non-ICU admitted patients	Transpl Infect Dis	NRCS <30 per arm
58	32492533	Rutsaert	COVID-19-associated invasive pulmonary aspergillosis	Ann Intensive Care	Outcome not of interest
59	32448770	Salehi	Opportunistic Fungal Infections in the Epidemic Area of COVID-19: A Clinical and Diagnostic Perspective from Iran	Mycopathologia	Narrative Review
60	32488446	Schwartz	Cutaneous manifestations of a 21st century worldwide fungal epidemic possibly complicating the COVID-19 pandemic to jointly menace mankind	Dermatol Ther	Case report or Case Series
61	32404482	Seeliger	Acute abdomen in patients with SARS-CoV-2 infection or co-infection	Langenbecks Arch Surg	Single group N<50
62	32645614	Sepulveda	Bacteremia and Blood Culture Utilization during COVID-19 Surge in New York City	J Clin Microbiol	Outcome not of interest
63	32745308	Shah	Clinical features, diagnostics, and outcomes of patients presenting with acute respiratory illness: a comparison of patients with and without COVID-19	medRxiv	Single group N<50
64	32645044	Shah	Clinical features, diagnostics, and outcomes of patients presenting with acute respiratory illness: A retrospective cohort study of patients with and without COVID-19	EClinicalMedicine	Single group N<50
65	32278670	Sharov	Adaptation of a Russian population to SARS-CoV-2: Asymptomatic course, comorbidities, mortality, and other respiratory viruses , A reply to Fear versus Data	International Journal of Antimicrobial Agents	Does not address RQ1-2
66	32613024	Shukla	Exposure to bushfire and biomass smoke and the risk of bacterial and viral lung infection	Respirology	Does not address RQ1-2
67	32664423	Strohbehn	COVIDOSE: Low-dose tocilizumab in the treatment of Covid-19	medRxiv	NRCS <30 per arm
68	32661615	Van Tan	SARS-CoV-2 and co-infections detection in nasopharyngeal throat swabs of COVID-19 patients by metagenomics	J Infect	Does not address RQ1-2
69	32462695	Thompson Iii	Invasive Aspergillosis as an Under-recognized Superinfection in COVID-19	Open Forum Infect Dis	Narrative Review
70	32511488	Tiri	Antimicrobial stewardship program, COVID-19, and infection control: Spread of carbapenem-resistant klebsiella pneumoniae colonization in ICU COVID-19 patients. What did not work?	Journal of Clinical Medicine	Single group N<50

71	32864588	van Arkel	Reply to: Fungal Infection During COVID-19: Does Aspergillus Mean Secondary Invasive Aspergillosis?	Am J Respir Crit Care Med	Narrative Review
72	32854334	Van Biesen	Detection of Invasive Pulmonary Aspergillosis in COVID-19 with Non-directed Bronchoalveolar Lavage	Am J Respir Crit Care Med	Single group N<50
73	32668167	Verroken	Co-infections in COVID-19 critically ill and antibiotic management: a prospective cohort analysis	Crit Care	Single group N<50
74	32646494	Verweij	Diagnosing COVID-19-associated pulmonary aspergillosis	Lancet Microbe	Narrative Review
75	32815458	Wee	Community-acquired viral respiratory infections amongst hospitalized inpatients during a COVID-19 outbreak in Singapore: co-infection and clinical outcomes	J Clin Virol	Does not address RQ1-2
76	32539942	Wee	Reduction in healthcare-associated respiratory viral infections during a COVID-19 outbreak	Clinical Microbiology and Infection	Does not address RQ1-2
77	32720012	Wu	Recognition and management of respiratory coinfection and secondary bacterial pneumonia in patients with COVID-19	Cleve Clin J Med	Narrative Review
78	32745596	Wu	Clinical Characteristics and Immune Injury Mechanisms in 71 Patients with COVID-19	mSphere	Does not address RQ1-2
79	32682358	Xiao	Development and validation of the HNC-LL score for predicting the severity of coronavirus disease 2019	EBioMedicine	Outcome not of interest
80	32603803	Yu	Profiles of liver function abnormalities in elderly patients with Coronavirus Disease 2019	International journal of clinical practice	Outcome not of interest
81	32293646	Yue	The epidemiology and clinical characteristics of co-infection of SARS-CoV-2 and influenza viruses in patients during COVID-19 outbreak	J Med Virol	Does not address RQ1-2
82	32574282	Zhang	Clinical characteristics of 82 cases of death from COVID-19	PLoS One	Outcome not of interest
83	32764228	Zhang	Risks and features of secondary infections in severe and critical ill COVID-19 patients	Emerging microbes & infections	Single group N<50
84	preprint	Ai	Optimizing diagnostic strategy for novel coronavirus pneumonia, a multi-center study in Eastern China	N/A	Single group N<50
85	preprint	Ai	The cross-sectional study of hospitalized coronavirus disease 2019 patients in Xiangyang, Hubei province	N/A	Does not address RQ1-2
86	preprint	Alanio	High prevalence of putative invasive pulmonary aspergillosis in critically ill COVID-19 patients	N/A	Single group N<50
87	preprint	Baluku	Prevalence, clinical characteristics and treatment outcomes of HIV and SARS-CoV-2 co-infection: a systematic review and meta-analysis	N/A	Does not address RQ1-2
88	preprint	Brill	COVID-19: a retrospective cohort study with focus on the over-80s and hospital-onset disease	N/A	Does not address RQ1-2
89	preprint	Buehler	Bacterial pulmonary superinfections are associated with unfavourable outcomes in critically ill COVID-19 patients	N/A	Single group N<50
90	preprint	Hern	Clinical characteristics and outcomes of patients with COVID-19 and ARDS admitted to a third level health institution in Mexico City	N/A	Does not address RQ1-2
91	preprint	Chakladar	Microbial contamination of powered air purifying respirators (PAPR) used during the COVID-19 pandemic: an in situ microbiological study	N/A	Does not address RQ1-2
92	preprint	Chang	Optimization of Microbiological Laboratory Detection Strategy for Patients in A Designated Hospital Treating Novel Coronavirus Pneumonia in Anhui Province	N/A	Single group enrolled N<50
93	preprint	Chen	Clinical Characteristics of Hospitalized Patients with SARS-CoV-2 and Hepatitis B virus Co-infection	N/A	Does not address RQ1-2
94	preprint	Cho	Clinical and intestinal histopathological findings in SARS-CoV-2/COVID-19 patients with hematochezia	N/A	Case report or Case Series
95	preprint	de Lamballerie	Transcriptional profiling of immune and inflammatory responses in the context of SARS-CoV-2 fungal superinfection in a human airway epithelial model	N/A	Does not address RQ1-2

96	preprint	Dhesi	Organisms causing secondary pneumonias in COVID-19 patients at 5 UK ICUs as detected with the FilmArray test	N/A	Outcome not of interest
97	preprint	Fan	Retrospective Analysis of Clinical Features in 101 Death Cases with COVID-19	N/A	Does not address RQ1-2
98	preprint	Fan	Medical treatment of 55 patients with COVID-19 from seven cities in northeast China who fully recovered: a single-center, retrospective, observational study	N/A	Does not address RQ1-2
99	preprint	Karmen-Tuohy	Outcomes among HIV-positive patients hospitalized with COVID-19	N/A	Single group N<50
100	preprint	Khonyongwa	Incidence and outcomes of healthcare-associated COVID-19 infections: significance of delayed diagnosis and correlation with staff absence	N/A	Does not address RQ1-2
101	preprint	Lopez-Medrano	Combination therapy with tocilizumab and corticosteroids for aged patients with severe COVID-19 pneumonia: a single-center retrospective study.	N/A	Does not address RQ1-2
102	preprint	Maes	Secondary pneumonia in critically ill ventilated patients with COVID-19	N/A	Single group N<50
103	preprint	Mansab	Patient-Led COVID-19 Triage Systems and Case Fatality Rates: A Comparative Study Between Singapore, Japan, Norway, the USA and the UK.	N/A	Does not address RQ1-2
104	preprint	Quartuccio	Profiling COVID-19 pneumonia progressing into the cytokine storm syndrome: results from a single Italian Centre study on tocilizumab versus standard of care.	N/A	Outcome not of interest
105	preprint	Reyes	Induction of a regulatory myeloid program in bacterial sepsis and severe COVID-19	N/A	Does not address RQ1-2
106	preprint	Rubio-Rivas	Beneficial Effect of Corticosteroids in Preventing Mortality in Patients Receiving Tocilizumab to Treat Severe COVID-19 Illness	N/A	Does not address RQ1-2
107	preprint	Sepulveda	Bacteremia and Blood Culture Utilization During COVID-19 Surge in New York City	N/A	Outcome not of interest
108	preprint	Serra Mitja	Bronchoscopy in critically ill COVID-19 Patients: microbiological profile and factors related to nosocomial respiratory infection	N/A	Outcome not of interest
109	preprint	Somers	Tocilizumab for treatment of mechanically ventilated patients with COVID-19	N/A	Outcome not of interest
110	preprint	Strohbehn	COVIDOSE: Low-dose tocilizumab in the treatment of Covid-19	N/A	Single group N<50
111	preprint	Sy	Previous and active tuberculosis increases risk of death and prolongs recovery in patients with COVID-19	N/A	Does not address RQ1-2
112	preprint	Wang	Clinical diagnosis of 8274 samples with 2019-novel coronavirus in Wuhan	N/A	Does not address RQ1-2
113	preprint	Wang	The definition and risks of Cytokine Release Syndrome-Like in 11 COVID-19-Infected Pneumonia critically ill patients: Disease Characteristics and Retrospective Analysis	N/A	Single group N<50
114	preprint	Xu	Clinical Characteristics of SARS-CoV-2 Pneumonia Compared to Controls in Chinese Han Population	N/A	Outcome not of interest
115	preprint	Zhang	Clinical features and outcomes of 221 patients with COVID-19 in Wuhan, China	N/A	Outcome not of interest
116	preprint	Zhong	Characterization of Microbial Co-infections in the Respiratory Tract of hospitalized COVID-19 patients	N/A	Single group N<50

Abbreviations: N/A = not applicable, PMID = PubMed Identifier, RQ = Research Question

Appendix Table 5: Quality assessment for all Key Questions – Single group studies, assessment of remaining biases and overall quality

Study, Year, PMID	RQ or objective clearly stated	Study population clearly specified and defined	Participation rate at least 50%	Subject selection	Exposure assessed prior to outcome measurement	Time to see an effect	Exposure measures	Repeated exposure assessment	Outcome measures	Blinding of outcome assessors	Follow up rate	Statistical analyses	Overall Risk of Bias
Adler, 2020, 32835331	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	HIGH
Bartoletti, 2020, 32719848	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	HIGH
Chauhdary, 2020, 32500854	Yes	No	Yes	Yes	No	N/A	No	No	No	No	N/A	No	HIGH
Chen, 2020, 32405109	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	No	No	CD	No	HIGH
Chen, 2020, preprint	Yes	Yes	Yes	Yes	Yes	CD	Yes	Yes	Yes	No	CD	No	HIGH
Du, 2020, 32255382	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	HIGH
Dudoignon, 2020, 32544219	Yes	Yes	Yes	Yes	Yes	CD	Yes	Yes	Yes	No	CD	No	HIGH
Garcia-Vidal, 2020, 32649747	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	HIGH
Gayam, 2020, 32449972	Yes	No	Yes	Yes	Yes	CD	Yes	Yes	Yes	No	CD	No	HIGH
Goncalves, 2020, 32808695	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
He, 2020, 32279676	Yes	No	Yes	Yes	Yes	CD	No	No	No	No	CD	No	HIGH
Henry, 2020, preprint	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	HIGH
Lehmann, 2020, 32604413	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	HIGH
Lendorf, 2020, 32800073	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	HIGH
Liu, 2020, 32312864	No	Yes	Yes	Yes	Yes	CD	Yes	No	No	No	CD	No	HIGH
Lv, 2020, 32425649	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Ma, 2020, 32922049	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	HIGH
Nasir, 2020, 32585069	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Nori, 2020, 32703320	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH

Study, Year, PMID	RQ or objective clearly stated	Study population clearly specified and defined	Participation rate at least 50%	Subject selection	Exposure assessed prior to outcome measurement	Time to see an effect	Exposure measures	Repeated exposure assessment	Outcome measures	Blinding of outcome assessors	Follow up rate	Statistical analyses	Overall Risk of Bias
Quartuccio, 2020, 32570043	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	HIGH
Richardson, 2020, 32320003	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	HIGH
Salehi, 2020, 32609906	Yes	Yes	Yes	Yes	No	N/A	No	No	Yes	No	N/A	No	HIGH
Van Arkel, 2020, 32396381	No	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Vaughn, 2020, 32820807	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	Yes	HIGH
Wang, 2020, 32240670	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	HIGH
Wang, 2020, 32354360	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	Yes	HIGH
Wang, 2020, 32503617	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Wei, 2020, preprint	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Williams, 2020, preprint	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	HIGH
Wolfe, 2020, preprint	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Wu, 2020, 32642086	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Xing, 2020, preprint	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Zha, 2020, 32652163	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Zhang, 2020, 32311650	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH
Zhu, 2020, 32408156	Yes	Yes	Yes	Yes	Yes	CD	Yes	No	Yes	No	CD	No	HIGH

Abbreviations: CD = cannot determine, N/A = not applicable, PMID = PubMed Identifier, RQ = Research Question

Ratings are color coded for emphasis only. The colors do not impart unique information.

From the National Heart, Lung, and Blood Institute (NHLBI) Quality Assessment Tool (each item rated as **Yes**, **No**, **CD**, or **N/A**)

- Eligibility criteria prespecified and clearly described: potentially related to selection bias;
- Intervention clearly described and delivered consistently: potentially related to performance bias;
- Outcomes prespecified, clearly defined, valid, reliable, and assessed consistently: potentially related to detection bias.

Overall risk of bias assessed as **HIGH**, **MODERATE**, or **LOW**.

Appendix Table 6: Risk of bias assessment for all Key Questions – NRCs and cohort studies

Study, Year, PMID	Potential for confounding	Potential for time-varying confounding	Intervention switches related to prognostic factors	Appropriate analysis method for confounding	Appropriate confounding variables used	Inappropriate control of post-intervention variables	Judgement – Risk of bias related to confounding	Participant selection based on post-intervention variables	Post intervention variables associated with intervention	Post intervention variables associated with outcome	Appropriate adjustment for selection bias	Judgement – Risk of bias related to selection bias	Overall RoB
Campochiaro, 2020, 32482597	Yes	Yes	No	No	No	No	HIGH	No	N/A	N/A	No	HIGH	HIGH
Kimmig, 2020, preprint	Yes	Yes	No	Yes	Yes	No	MODERATE	No	N/A	N/A	No	HIGH	HIGH
Pettit, 2020, 32790075	Yes	Yes	No	No	No	No	HIGH	No	N/A	N/A	No	HIGH	HIGH
Rinaldi, 2020, 32779808	Yes	Yes	No	Yes	Yes	No	MODERATE	No	N/A	N/A	No	HIGH	HIGH
Wu, 2020, 32642086	Yes	Yes	No	Yes	Yes	No	MODERATE	No	N/A	N/A	Yes	LOW	MODERATE

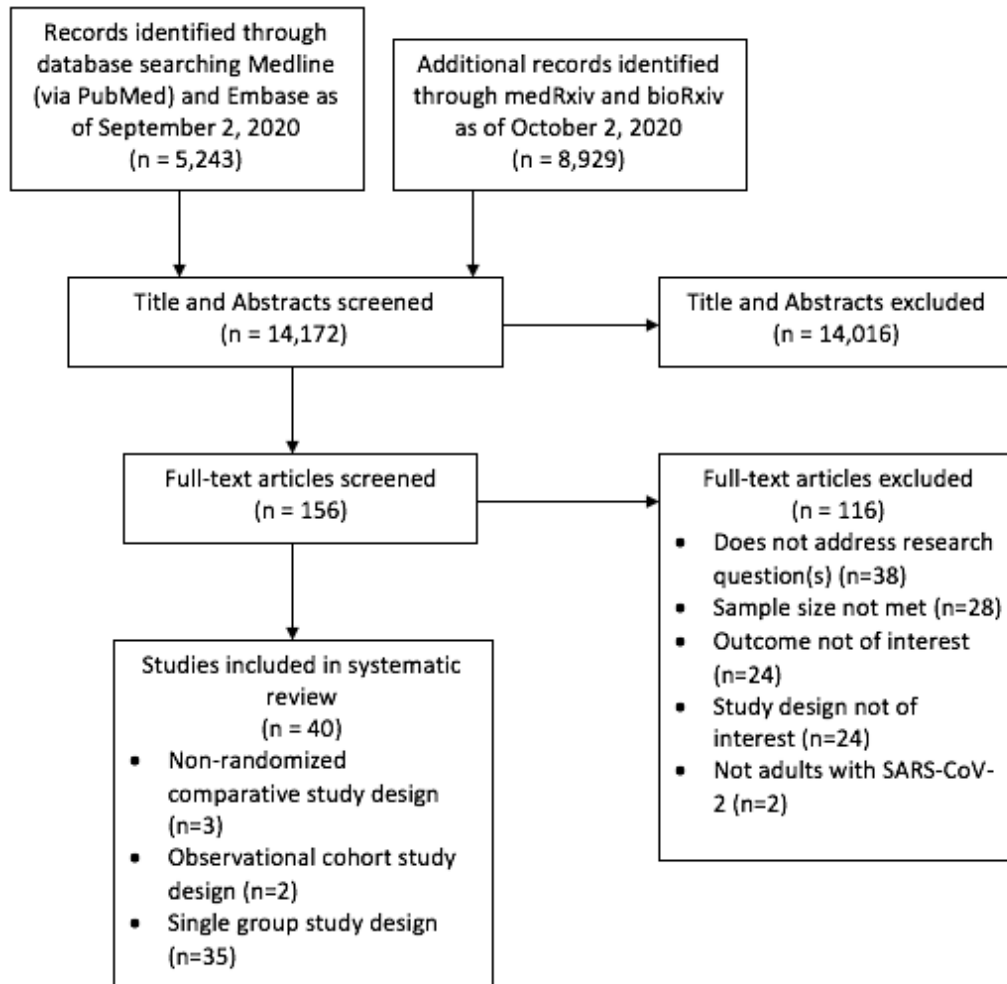
Abbreviations: PMID = PubMed Identifier, Responses to Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I)
Ratings are color coded for emphasis only. The colors do not impart unique information.

From the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) (each item rated as Yes, No)

- Studies of Interventions (ROBINS-I) signaling questions 1.1 to 1.6 and 2.1 to 2.5 are in regular font. Each item rated as High, PY (probably High), NI (Low information), PN (probably Low), Low, or N/A (Not applicable).

Overall risk of bias assessed as **HIGH**, **MODERATE**, or **LOW**.

Appendix Figure 1: PRISMA Flow Diagram – Selection of studies



Appendix Table 7. Research Question 1: Incidence or prevalence of bacterial and/or fungal coinfections – Summary design, arm, sample details

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Risk of Bias	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX (%)	Antifungal use (%)
Adler, 2020, 32835331, UK	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: PCR-confirmed COVID-19	Blood culture	Streptococcus pneumoniae	195	Median: 69 IQR: 59-81	12.3	NR	NR	NR
Bartoletti, 2020, 32719848, Italy	Single group (Prospective) (None) (Feb. 2020 – Apr. 2020)	High	I: ≥18 yr, ICU RT-PCR confirmed COVID-19 receiving MV E: early ICU discharge (<48 h)	RT-PCR assay	Pulmonary aspergillosis	108	Median: 64 IQR: 57-70	100	100	NR	53
Campochiaro, 2020, 32482597, Italy	NRCS (Retrospective) (NR) (Mar. 2020 – Mar. 2020)	High	I: RT-PCR confirmed COVID-19, E: Concomitant bacterial infection	NR	NR	65	Arm 1: Median: 64; IQR: 53-75 Arm 2: Median: 60; IQR: 55-75.5	NR	Arm 1: 78 Arm 2: 61	NR	NR
Chauhdary, 2020, 32500854, Brunei	Single group (NR) (NR) (NR)	High	I: Confirmed COVID-19	NR	Streptococcus pneumoniae, Klebsiella pneumoniae, Haemophilus influenzae	141	NR	NR	NR	NR	NR
Chen, 2020, 32405109, China	Single group (NR) (None) (Jan, 2020 – Mar. 2020)	High	I: PCR-confirmed COVID-19	NR	NR	51	59.5 (13.6)	55	88.2	100	16
Chen, 2020, preprint, China	Single group (Retrospective) (NR) (Jan. 2020 - Feb. 2020)	High	I: RT-PCR confirmed COVID-19	Antibody test	Mycoplasma pneumoniae, Chlamydia pneumonia	291	Median: 46; IQR: 34-59	NR	NR	NR	NR
Du, 2020, 32255382, China	Single group (Retrospective) (NR) (Dec. 2019 – Feb. 2020)	High	I: Positive SARS-CoV-2 result in throat-swab specimens	NR	NR	109	70.7 (10.9)	46.8	NI: 58.7 INV: 30.3	100	18.3
Dudoignon, 2020, 32544219, France	Single group (Prospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: ICU for respiratory failure related to COVID-19, ≥18 yr	Bronchoscopic bronchoalveolar lavage	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	54	Median: 63; IQR: 57-68	NR	NR	NR	NR
Garcia-Vidal, 2020, 32649747, Spain	Single group (NR) (None) (Mar. 2020 – Apr. 2020)	High	I: PCR-confirmed COVID-19	Microbiological culture, urinary antigen test	Streptococcus pneumoniae, Invasive candidiasis	246	NR	NR	NR	NR	NR

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Risk of Bias	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX (%)	Antifungal use (%)
Gayam, 2020, 32449972, USA	Single group (Retrospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: COVID-19	Sputum, urine, and blood cultures	Mycoplasma pneumoniae	350	NR	1	NR	NR	NR
Goncalves, 2020, 32808695, USA	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, >18 yr	Positive blood, sputum, urine, or tissue culture	NR	242	71.4 (11.2)	NR	NR	NR	NR
He, 2020, 32279676, China	Single group (Retrospective) (Non-industry) (Dec. 2019 – Feb. 2020)	High	I: COVID-19 patients	NR	Coagulase negative staphylococcus, Acinetobacter, Pseudomonas aeruginosa, Enterococcus faecium, Klebsiella pneumoniae, Escherichia coli, Candida albicans, Mucor	918	NR	NR	NR	NR	NR
Henry, 2020, preprint, USA	Single group (Prospective) (NR) (Apr. 2020 – May 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	Positive blood or urine bacterial culture	NR	52	Median: 51 IQR: 39-66	NR	NR	NR	NR
Kimmig, 2020, preprint, NR	Single group (Retrospective) (Non-industry) (Mar. 2020 – Apr. 2020)	High	I: COVID-19 ICU patients	NR	NR	111	63.2*	100	NR	NR	NR
Lehmann, 2020, 32604413, USA	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	PCR	Staphylococcus aureus, Proteus mirabilis, S. pneumoniae, Candida and Aspergillus fumigatus	321	60 (17)	5	NR	NR	NR
Lendorf, 2020, 32800073, Denmark	Single group (Retrospective) (None) (Mar. 2020 – May 2020)	High	I: RT-PCR confirmed COVID-19	Positive culture or PCR	Klebsiella pneumoniae, Escherichia coli, Haemophilus influenzae, Pseudomonas aeruginosa, staphylococcus aureus, Proteus mirabilis, Moraxella catarrhalis, enterococcus faecalis, legionella species, Candida albicans	111	Median: 68 IQR: 56-78	18	NI: 5 INV: 11	NR	NR
Liu, 2020, 32312864, China	Single group (NR) (Non-industry) (Mar. 2020)	High	I: COVID-19 positive response to viral nucleic acid detection	NR	NR	221	NR	NR	NR	NR	NR
Lv, 2020, 32425649, China	Single group (Retrospective) (NR) (Feb. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	Bronchoalveolar lavage fluids or blood cultures	A. baumannii, Staphylococcus haemolyticus, Escherichia coli, Candida tropicalis, C. albicans, Pseudomonas aeruginosa Stenotrophomonas maltophilia, Enterococcus faecium, Candida parapsilosis, Candida lusitanae	354	Median: 62 Range: 23-90	NR	NR	NR	NR
Ma, 2020, 32922049, China	Single group (Retrospective) (NR) (Jan. 2020 – Feb. 2020)	High	I: Diagnosed with COVID-19	Chemiluminescence immunoassays	Mycoplasma pneumoniae, Chlamydia pneumonia	250	NR	NR	NR	NR	NR
Nasir, 2020, 32585069, Pakistan	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	Aspergillus-positive smear and culture of tracheal aspirate	Aspergillus	147	NR	15.6	NR	NR	NR

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Risk of Bias	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX (%)	Antifungal use (%)
Nori, 2020, 32703320, USA	Single group (Retrospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: PCR-confirmed COVID-19	Positive blood or respiratory culture	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	4267	NR	NR	NR	NR	NR
Pettit, 2020, 32790075, NR	NRCS (Retrospective) (None) (Mar. 2020 – May 2020)	High	I: COVID-19 who received ≥ 1 400 mg dose of TCZ for CRS.	Positive culture or nucleic acid amplification test	Mucor pneumonia, C. albicans fungemia, Aspergillus pneumonia, Coagulase negative Staphylococcus, MSSA, C. perfringens, C. albicans, MRSA, E. coli, Enterobacter, Pseudomonas, Acinetobacter	148	Arm 1: 66 (13.7) Arm 2: 65 (16.3)	70	32.4	NR	NR
Quartuccio, 2020, 32570043, Italy	Single group (Retrospective) (None) (Feb. 2020 – Apr. 2020)	High	I: Diagnosed with COVID-19	NR	NR	111	58.5 (13.6)	NR	NR	18.9	NR
Richardson, 2020, 32320003, USA	Single group (NR) (Non-industry) (Mar. 2020 – Apr. 2020)	High	I: PCR confirmed COVID-19	NR	Chlamydia pneumoniae, Mycoplasma pneumoniae	1996	NR	NR	NR	NR	NR
Rinaldi, 2020, 32779808, Italy	Cohort study (Prospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19	NR	Pulmonary aspergillosis, invasive candidiasis	885	Median: 69 IQR: 57-80	NR	NR	NR	NR
Salehi, 2020, 32609906, Iran	Single group (NR) (Non-industry) (Mar. 2020 – Apr. 2020)	High	I: Clinically and laboratory confirmed COVID-19	PCR	Candida, C. albicans	1059	NR	NR	NR	NR	NR
Somers, 2020, 32651997, USA	NRCS (NR) (Non-industry) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed severe COVID-19 requiring MV	NR	Staphylococcus aureus, Enterococcus, Candida	154	58 (14.9)	NR	100	NR	NR
van Arkel, 2020, 32396381, Netherlands	Single group (NR) (NR) (NR)	High	I: Laboratory-confirmed COVID-19	Bronchoalveolar lavage fluids	Aspergillus	135	NR	NR	NR	NR	NR
Vaughn, 2020, 32820807, USA	Single group (NR) (Industry) (Mar. 2020 – June 2020)	High	I: PCR confirmed COVID-19, ≥ 18 yr	Positive blood, respiratory, antigen, or PCR test	NR	1705	Median: 64.7 IQR: 53, 76.7	10.9	NI: 0.8 INV: 6.8	NR	NR
Wang, 2020, 32240670, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19, >60 yr	NR	NR	339	71 IQR: 65-76	NR	NR	NR	NR
Wang, 2020, 32354360, China	Single group (Retrospective) (Non-industry) (NR – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	NR	Staphylococcus caprae, Acinetobacter baumannii	107	Median: 51, IQR: 36-65	NR	NI: 6.5 INV: 15.9	79.4	NR

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Risk of Bias	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX (%)	Antifungal use (%)
Wang, 2020, 32503617, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: PCR confirmed COVID-19	Positive sputum or bronchoalveolar lavage fluid	Invasive pulmonary aspergillosis	104	63*	25	14.4	50	NR
Wei, 2020, preprint, USA	Single group (Prospective) (None) (Mar. 2020 – Apr. 2020)	High	I: PCR confirmed COVID-19, ≥18 yr	PCR panel	NR	147	52 (18)	NR	21	59	NR
Williams, 2020, preprint, UK	Single group (Retrospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	NR	MRSA, Clostridioides difficile	368	Median: 75 IQR: 60-83	13	8.7	NR	NR
Wolfe, 2020, preprint, USA	Single group (NR) (NR) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, nursing home and assisted living patients	RT-PCR	Staphylococcus aureus, Klebsiella pneumoniae, Haemophilus influenzae, Streptococcus pneumoniae	1413	NR	NR	NR	NR	NR
Wu, 2020, 32642086, China	Cohort (Retrospective) (None) (Jan. 2020 – Mar. 2020)	Moderate	I: RT-PCR confirmed COVID-19, >40 yr	NR	NR	1048	Arm 1: Median: 71 IQR: 65.8-77.9 Arm 2: Median: 56 IQR: 48-64.9	NR	NR	NR	NR
Xing, 2020, preprint, China	Single group (NR) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: Laboratory-confirmed COVID-19	Positive results for serum IgM antibody	Mycoplasma pneumoniae, Legionella pneumophila, Chlamydia pneumoniae, Coxiella burnetii	68	NR	NR	NR	NR	NR
Zha, 2020, 32652163, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Mar. 2020)	High	I: RT-PCR confirmed COVID-19	IgM chemiluminescence immunoassay	Mycoplasma pneumoniae	874	NR	NR	NR	NR	NR
Zhang, 2020, 32311650, China	Single group (Retrospective) (NR) (Jan. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	NR	NR	221	Median: 55 IQR: 39-66.5	NR	NR	NR	NR
Zhu, 2020, 32408156, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	Pathogen specific RT-PCR	Mycoplasma pneumoniae, Chlamydia pneumoniae, Legionella pneumophila, Haemophilus influenzae, Moraxella catarrhalis, Klebsiella pneumoniae, Streptococcus pneumoniae, Mycobacterium tuberculosis, Escherichia coli, Staphylococcus aureus, Acinetobacter baumannii, Pseudomonas aeruginosa, pneumocystis carinii, Bordetella pertussis and fungi	257	Median: 51 Range: 2-99	NR	NR	NR	NR

Abbreviations: ABX = antibiotics, E = exclusion, h = hour, I = inclusion, h = hours, ICU = intensive care unit, IGM = Immunoglobulin M, INV = invasive; mo = month, IQR = interquartile range, MV = mechanical ventilation, NI = non-invasive, NR = not reported, PCR = polymerase chain reaction, PMID = PubMed ID, RoB = risk of bias, RT-PCR = reverse transcription polymerase chain reaction, SD = standard deviation, spp. = species, yr = year, * = calculated

Table 8. Research Question 1: Incidence of bacterial coinfections – Categorical outcome (Bacterial coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	Follow up	n/N (%)
Adler, 2020, 32835331	Single group	High	Streptococcus pneumoniae	7 d	5/137 (3.6)
Chen, 2020, preprint	Single group	High	Mycoplasma pneumoniae	NR	29/291 (10)
Chen, 2020, preprint	Single group	High	Chlamydia pneumoniae	NR	22/291 (7.6)
Dudoignon, 2020, 32544219	Single group	High	NR	5 d	20/54 (37)
Garcia-Vidal, 2020, 32649747	Single group	High	Streptococcus pneumoniae	5 d	1/246 (0.4)
Gayam, 2020, 32449972	Single group	High	Mycoplasma pneumoniae	NR	6/350 (1.7)
Henry, 2020, preprint	Single group	High	NR	30 d	8/52 (15.4)
Lehmann, 2020, 32604413	Single group	High	Staphylococcus aureus, Proteus mirabilia, S. pneumoniae	5 d	7/321 (2.2)
Lendorf, 2020, 32800073	Single group	High	Klebsiella pneumoniae, Escherichia coli, Haemophilus influenzae, Pseudomonas aeruginosa, staphylococcus aureus, Proteus mirabilis, Moraxella catarrhalis, enterococcus faecalis, legionella species	30 d	13/111 (11.7)
Liu, 2020, 32312864	Single group	High	NR	NR	17/221 (7.7)
Ma, 2020, 32922049	Single group	High	Mycoplasma pneumoniae, Chlamydia pneumoniae	14-28 d	21/250 (8.4)
Quartuccio, 2020, 32570043	Single group	High	NR	17.8 d	18/111 (16.2)
Richardson, 2020, 32320003	Single group	High	Mycoplasma pneumoniae	4.5 d	1/1996 (0.1)
Richardson, 2020, 32320003	Single group	High	Chlamydia pneumoniae	4.5 d	2/1996 (0.1)
Rinaldi, 2020, 32779808	Cohort	High	NR	30 d	142/885 (16.4)
Vaughn, 2020, 32820807	Single group	High	NR	7 d	59/1705 (3.5)
Wang, 2020, 32240670	Single group	High	NR	28 d	143/339 (42.2)
Wei, 2020, preprint	Single group	High	NR	NR	10/147 (7)
Williams, 2020, preprint	Single group	High	MRSA	28 d	1/368 (0.3)
Williams, 2020, preprint	Single group	High	Clostridioides difficile	28 d	0/368 (0)
Zhang, 2020, 32311650	Single group	High	NR	NR	17/221 (7.7)

Abbreviations: d = days, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 9. Research Question 1: Prevalence of bacterial coinfections – Categorical outcome (Bacterial coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	n/N (%)
Chauhdary, 2020, 32500854	Single group	High	Streptococcus pneumoniae, Klebsiella pneumoniae, Haemophilus influenzae	5/141 (3.5)
Chen, 2020, 32405109	Single group	High	NR	11/51 (22)
Goncalves, 2020, 32808695	Single group	High	NR	46/242 (19)
Kimmig, 2020, preprint	Single group	High	NR	42/111 (37.8)
Wang, 2020, 32354360	Single group	High	NR	5/107 (4.7)
Wolfe, 2020, preprint	Single group	High	Staphylococcus aureus, Klebsiella pneumoniae, Haemophilus influenzae, Streptococcus pneumoniae	1082/1413 (76.6)
Xing, 2020, preprint	Single group	High	Mycoplasma pneumoniae	8/68 (11.8)
Xing, 2020, preprint	Single group	High	Legionella pneumophila	6/68 (8.8)
Xing, 2020, preprint	Single group	High	Chlamydia pneumoniae	0/68 (0)
Xing, 2020, preprint	Single group	High	Coxiella burnetii	0/68 (0)
Zha, 2020, 32652163	Single group	High	Mycoplasma pneumoniae	22/874 (2.5)
Zhu, 2020, 32408156	Single group	High	NR	236/257 (91.8)

Abbreviations: NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 10. Research Question 1: Incidence of fungal coinfections – Categorical outcome (Fungal coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	Follow up	n/N (%)
Bartoletti, 2020, 32719848	Single group	High	Pulmonary aspergillosis	7 d	30/108 (27.7)
Garcia-Vidal, 2020, 32649747	Single group	High	Invasive candidiasis	5 d	1/246 (0.4)
Lehmann, 2020, 32604413	Single group	High	Candida and Aspergillus fumigatus	5 d	11/321 (3.4)
Lendorf, 2020, 32800073	Single group	High	Candida albicans	30 d	1/111 (0.9)
Nasir, 2020, 32585069	Single group	High	Aspergillus	8 d	9/147 (6.1)
Rinaldi, 2020, 32779808	Cohort	High	Pulmonary aspergillosis	30 d	12/885 (1.4)
Rinaldi, 2020, 32779808	Cohort	High	Invasive candidiasis	30 d	3/885 (0.3)
van Arkel, 2020, 32396381	Single group	High	Aspergillus fumigatus	NR	6/135 (4.4)
Zhang, 2020, 32311650	Single group	High	NR	NR	7/221 (3.2)

Abbreviations: d = days, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 11. Research Question 1: Prevalence of fungal coinfections – Categorical outcome (Fungal coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	n/N (%)
Chen, 2020, 32405109	Single group	High	NR	6/51 (12)
Kimmig, 2020, preprint	Single group	High	NR	3/111 (2.7)
Salehi, 2020, 32609906	Single group	High	Candida, Candida albicans	53/1059 (5)
Wang, 2020, 32503617	Single group	High	Invasive pulmonary aspergillosis	8/104 (7.7)
Zhu, 2020, 32408156	Single group	High	NR	60/257 (23.3)

Abbreviations: NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 12. Research Question 1: Incidence of bacterial and/or fungal coinfections – Categorical outcome (Bacterial or fungal coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	Follow up	n/N (%)
Campochiaro, 2020, 32482597	NRCS	High	NR	28 d	8/44 (18.2)
Du, 2020, 32255382	Single group	High	NR	NR	42/109 (38.5)
Lendorf, 2020, 32800073	Single group	High	Klebsiella pneumoniae, Escherichia coli, Haemophilus influenzae, Pseudomonas aeruginosa, staphylococcus aureus, Proteus mirabilis, Moraxella catarrhalis, enterococcus faecalis, legionella species, Candida albicans	30 d	14/111 (13)
Nori, 2020, 32703320	Single group	High	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp. and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp., Enterococcus spp., Escherichia coli, Pseudomonas aeruginosa, Candida spp., Klebsiella spp., Enterobacter spp.	NR	152/4267 (3.6)
Pettit, 2020, 32790075	NRCS	High	NR	Mean: 58 d	25/148 (16.9)
Somers, 2020, 32651997	NRCS	High	NR	Mean: 47 d Range: 28-67 d	65/154 (42.2)
Wu, 2020, 32642086	Cohort	Moderate	NR	NR	69/1048 (6.6)

Abbreviations: d = days, NR = not reported, NRCS = nonrandomized comparative study, PMID = PubMed ID, RoB = risk of bias

Table 13. Research Question 1: Prevalence of bacterial and/or fungal coinfections – Categorical outcome (Bacterial or fungal coinfection)

Study, Year, PMID	Design	Overall RoB	Type of pathogen	n/N (%)
He, 2020, 32279676	Single group	High	Coagulase negative staphylococcus, Acinetobacter, Pseudomonas aeruginosa, Enterococcus faecium, Klebsiella pneumoniae, Escherichia coli, Candida albicans, Mucor	65/918 (7.1)
Lv, 2020, 32425649	Single group	High	A. baumannii, Staphylococcus haemolyticus, Escherichia coli, Candida tropicalis, C. albicans, Pseudomonas aeruginosa, Stenotrophomonas maltophilia, Enterococcus faecium, Candida parapsilosis, Candida lusitanae	20/354 (5.6)
Zhu, 2020, 32408156	Single group	High	NR	61/257 (23.7)

Abbreviations: NR = not reported, PMID = PubMed ID, RoB = risk of bias

Appendix Table 14. Research Question 2: Risk factors of bacterial and/or fungal coinfections – Summary design, arm, sample details

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Overall RoB	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX use (%)	Antifungal use (%)
Bartoletti, 2020, 32719848, Italy	Single group (Prospective) (None) (Feb. 2020 – Apr. 2020)	High	I: ≥18 yr, ICU RT-PCR confirmed COVID-19 receiving MV E: early ICU discharge (<48 h)	RT-PCR assay	Pulmonary aspergillosis	108	Median: 64 IQR: 57-70	100	100	NR	53
Chen, 2020, 32405109, China	Single group (NR) (None) (Jan. 2020 – Mar. 2020)	High	I: PCR-confirmed COVID-19	NR	NR	51	59.5 (13.6)	55	88.2	100	16
Chen, 2020, preprint, China	Single group (Retrospective) (NR) (Jan. 2020 - Feb. 2020)	High	I: RT-PCR confirmed COVID-19	Antibody test	Mycoplasma pneumoniae, Chlamydia pneumonia	297	Median: 46; IQR: 34-59	NR	NR	NR	NR
Dudoignon, 2020, 32544219, France	Single group (Prospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: ICU for respiratory failure related to COVID-19, ≥18 yr	Bronchoscopy bronchoalveolar lavage	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia, Pseudomonas aeruginosa, Stenotrophomonas maltophilia	54	Median: 63; IQR: 57-68	NR	NR	NR	NR
Gayam, 2020, 32449972, USA	Single group (Retrospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: COVID-19	Sputum, urine, and blood cultures	Mycoplasma pneumoniae	350	NR	1	NR	NR	NR
Goncalves, 2020, 32808695, USA	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, >18 yr	Positive blood, sputum, urine, or tissue culture	NR	242	71.4 (11.2)	NR	NR	NR	NR
Henry, 2020, preprint, USA	Single group (Prospective) (NR) (Apr. 2020 – May 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	Positive blood or urine bacterial culture	NR	52	Median: 51 IQR: 39-66	NR	NR	NR	NR
Lendorf, 2020, 32800073, Denmark	Single group (Retrospective) (None) (Mar. 2020 – May 2020)	High	I: RT-PCR confirmed COVID-19	Positive culture or PCR	Klebsiella pneumoniae, Escherichia coli, Haemophilus influenzae, Pseudomonas aeruginosa, staphylococcus aureus, Proteus mirabilis, Moraxella catarrhalis, enterococcus faecalis, legionella species, Candida albicans	111	Median: 68 IQR: 56-78	18	NI: 5 INV: 11	NR	NR
Liu, 2020, 32312864, China	Single group (NR) (Non-industry) (Mar. 2020)	High	I: COVID-19 positive response to viral nucleic acid detection	NR	NR	221	NR	NR	NR	NR	NR

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Overall RoB	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX use (%)	Antifungal use (%)
Lv, 2020, 32425649, China	Single group (Retrospective) (NR) (Feb. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	Bronchoalveolar lavage fluids or blood cultures	A. baumannii, Staphylococcus haemolyticus, Escherichia coli, Candida tropicalis, C. albicans, Pseudomonas aeruginosa Stenotrophomonas maltophilia, Enterococcus faecium, Candida parapsilosis, Candida lusitanae	354	Median: 62 Range: 23-90	NR	NR	NR	NR
Ma, 2020, 32922049, China	Single group (Retrospective) (NR) (Jan. 2020 – Feb. 2020)	High	I: Diagnosed with COVID-19	Chemiluminescence immunoassays	Mycoplasma pneumoniae, Chlamydia pneumonia	250	NR	NR	NR	NR	NR
Nasir, 2020, 32585069, Pakistan	Single group (Retrospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, ≥18 yr	Aspergillus-positive smear and culture of tracheal aspirate	Aspergillus	147	NR	15.6	NR	NR	NR
Nori, 2020, 32703320, USA	Single group (Retrospective) (NR) (Mar. 2020 – Apr. 2020)	High	I: PCR-confirmed COVID-19	Positive blood or respiratory culture	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	4267	NR	NR	NR	NR	NR
Rinaldi, 2020, 32779808, Italy	Cohort (Prospective) (None) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19	NR	Pulmonary aspergillosis, invasive candidiasis	885	Median: 69 IQR: 57-80	NR	NR	NR	NR
Salehi, 2020, 32609906, Iran	Single group (NR) (Non-industry) (Mar. 2020 – Apr. 2020)	High	I: Clinically and laboratory confirmed COVID-19	PCR	Candida, C. albicans	1059	NR	NR	NR	NR	NR
van Arkel, 2020, 32396381, Netherlands	Single group (NR) (NR) (NR)	High	I: Laboratory-confirmed COVID-19	Bronchoalveolar lavage fluids	Aspergillus	135	NR	NR	NR	NR	NR
Vaughn, 2020, 32820807, USA	Single group (NR) (Industry) (Mar. 2020 – June 2020)	High	I: PCR confirmed COVID-19, ≥18 yr	Positive blood, respiratory, antigen, or PCR test	NR	1705	Median: 64.7 IQR: 53, 76.7	10.9	NI: 0.8 INV: 6.8	NR	NR
Wang, 2020, 32240670, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19, >60 yr	NR	NR	339	Median: 69 IQR: 65-76	NR	NR	NR	NR
Wang, 2020, 32354360, China	Single group (Retrospective) (Non-industry) (NR – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	NR	Staphylococcus caprae, Acinetobacter baumannii	107	Median: 51, IQR: 36-65	NR	NI: 6.5 INV: 15.9	79.4	NR

Study, Publication Year, PMID, Country	Design (Directionality) (Funding) (Study mo, yr)	Overall RoB	Eligibility Criteria	Bacteria or fungal diagnostic method (only reported details)	Type of pathogen (only reported details)	N	Age in Years, Mean (SD) or as specified	ICU (%)	MV (%)	ABX use (%)	Antifungal use (%)
Wang, 2020, 32503617, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Feb. 2020)	High	I: PCR confirmed COVID-19	Positive sputum, bronchoalveolar lavage fluid	Invasive pulmonary aspergillosis	104	63*	25	14.4	50	NR
Wolfe, 2020, preprint, USA	Single group (NR) (NR) (Mar. 2020 – Apr. 2020)	High	I: RT-PCR confirmed COVID-19, nursing home and assisted living patients	RT-PCR	Staphylococcus aureus, Klebsiella pneumoniae, Haemophilus influenzae, Streptococcus pneumoniae	1413	NR	NR	NR	NR	NR
Wu, 2020, 32642086, China	Cohort (Retrospective) (None) (Jan. 2020 – Mar. 2020)	Moderate	I: RT-PCR confirmed COVID-19, >40 yr	NR	NR	1048	NR	NR	NR	NR	NR
Zha, 2020, 32652163, China	Single group (Retrospective) (Non-industry) (Jan. 2020 – Mar. 2020)	High	I: RT-PCR confirmed COVID-19	IgM chemiluminescence immunoassay	Mycoplasma pneumoniae	874	NR	NR	NR	NR	NR
Zhang, 2020, 32311650, China	Single group (Retrospective) (NR) (Jan. 2020 – Feb. 2020)	High	I: RT-PCR confirmed COVID-19	NR	NR	221	Median: 55 IQR: 39-66.5	NR	NR	NR	NR

Abbreviations: ABX = antibiotics, E = exclusion, h = hour, I = inclusion, h = hours, ICU = intensive care unit, IGM = Immunoglobulin M, INV = invasive; mo = month, IQR = interquartile range, MV = mechanical ventilation, NI = non-invasive, NR = not reported, PCR = polymerase chain reaction, PMID = PubMed ID, RoB = risk of bias, RT-PCR = reverse transcription polymerase chain reaction, SD = standard deviation, yr = year, * = calculated

Table 15. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Age)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)	Unadj. P Value
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	≥60 yr	3/6 (50)	
Liu, 2020, 32312864	Single group	High	Bacterial	NR	Incidence	NR	≥60 yr	11/85 (12.9)	0.021
							<60 yr	6/136 (4.4)	
van Arkel, 2020, 32396381	Single group	High	Fungal	Aspergillus fumigatus	Incidence	NR	≥60 yr	3/6 (50)	
Salehi, 2020, 32609906	Single group	High	Fungal	Candida, C. albicans	Prevalence	NA	≥50 yr	42/53 (79.3)	

Abbreviations: NA = not applicable, NR = not reported, PMID = PubMed ID, unadj. = unadjusted, RoB = risk of bias, yr = years

Table 16. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (BMI – Obesity)

Study, Year, PMID	Outcome Measurement	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Bartoletti, 2020, 32719848	Incidence	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with obesity	10/44 (22.7)

Abbreviations: d = days, PMID = PubMed ID, RoB = risk of bias

Table 17. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Race/ethnicity, African American [AA])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Race/ethnicity	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	AA patients	5/6 (83.3)
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	AA patients	22/59 (37.3)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	AA patients	27/171 (15.8)
Nori, 2020, 32703320	Single group	High	Bacterial or fungal	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	Incidence	NR	AA patients	60/152 (39.5)

Abbreviations: AA = African American, d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 18. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Race/ethnicity, Asian)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Race/ethnicity	n/N (%)
Nori, 2020, 32703320	Single group	High	Bacterial or fungal	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	Incidence	NR	Asian patients	9/152 (5.9)

Abbreviations: NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 19. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Race/ethnicity, Hispanic)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Race/ethnicity	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Hispanic patients	1/6 (16.7)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Hispanic patients	6/23 (13)
Nori, 2020, 32703320	Single group	High	Bacterial or fungal	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	Incidence	NR	Hispanic patients	48/152 (31.6)

Abbreviations: NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 20. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Race/ethnicity, White)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Race/ethnicity	n/N (%)
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	White patients	33/59 (55.9)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	White patients	3/17 (17.6)
Nori, 2020, 32703320	Single group	High	Bacterial or fungal	S. aureus, P. aeruginosa, Klebsiella spp, Enterobacter spp, and E. coli, Staphylococcus aureus, S. epidermidis, Streptococcus spp, Enterococcus spp Escherichia coli, Pseudomonas aeruginosa, Candida spp, Klebsiella spp, Enterobacter spp	Incidence	NR	White patients	11/152 (7.2)

Abbreviations: d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 21. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Sex)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Dudoignon, 2020, 32544219	Single group	High	Bacterial	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	Incidence	5 d	Female	4/12 (33.3)
							Male	16/42 (38.1)
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	Female	32/820 (3.9)
							Male	27/885 (3.1)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Female	23/119 (19.3)
							Male	23/123 (18.7)
Wolfe, 2020, preprint	Single group	High	Bacterial	Staphylococcus aureus, Klebsiella pneumoniae, Haemophilus influenzae, Streptococcus pneumoniae	Prevalence	NA	Female	750/991 (75.7)
							Male	332/422 (78.7)
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Female	11/54 (20.4)
							Male	11/56 (19.6)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Female	0/42 (0)
							Male	8/62 (12.9)

Abbreviations: d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 22. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical Outcome (Severity)

Study, Year, PMID	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Definition of severity	Severity	n/N (%)	Unadj. P Value
Chen, 2020, preprint	High	Bacterial	M. pneumoniae	Incidence	NR	<u>Severe</u> : respiratory distress, respiratory rate \geq 30 times/min, fingertip oxygen saturation \leq 93% in resting rate, arterial oxygen partial pressure/fraction of inspired oxygen \leq 300 mmHg; <u>Critical</u> : respiratory failure need MV, shock, other organ failure need ICU monitor and treatment	Severe/Critical /ICU	9/50 (18)	NR
.	.	.	.	.	.	Fever, respiratory tract, other symptoms with pneumonia	Mild/Moderate /Non-ICU	10/212 (4.7)	NR
.	.	Bacterial	C. pneumonia	Incidence	NR	<u>Severe</u> : respiratory distress, respiratory rate \geq 30 times/min, fingertip oxygen saturation \leq 93% in resting rate, arterial oxygen partial pressure/fraction of inspired oxygen \leq 300 mmHg; <u>Critical</u> : respiratory failure need MV, shock, other organ failure need ICU monitor and treatment	Severe/Critical /ICU	3/50 (6)	NR
.	.	.	.	.	.	Mild clinical symptoms w/o pneumonia	Mild/Moderate /Non-ICU	11/29 (37.9)	NR
Henry, 2020, preprint	High	Bacterial	NR	Incidence	30 d	Hospitalized, NIV or MV or high flow oxygen devices, requiring ICU admission; multi-organ dysfunction syndrome, ECMO, renal replacement therapy, death	Severe/Critical /ICU	6/8 (75)	NR
.	.	.	.	.	.	<u>Mild</u> : Not hospitalized/ambulatory, no limitations of activities <u>Moderate</u> : hospitalized, oxygen therapy or supplemental oxygen by mask or nasal cannula	Mild/Moderate /Non-ICU	2/8 (25)	NR
Ma, 2020, 32922049	High	Bacterial	M. pneumoniae, C. pneumonia	Incidence	14-28 d	NR	Severe/Critical /ICU	11/21 (52.4)	NR
.	.	.	.	.	.	.	Mild/Moderate /Non-ICU	10/21 (47.7)	NR
Zhang, 2020, 32311650	High	Bacterial	NR	Incidence	NR	International guidelines for community-acquired pneumonia	Severe/Critical /ICU	14/55 (25.5)	<0.001
.	.	.	.	.	.	.	Mild/Moderate /Non-ICU	3/166 (1.8)	
Chen, 2020, 32405109	High	Bacterial	NR	Prevalence	NA	Trial v7 Guidelines of China	Severe/Critical /ICU	11/51 (21.6)	NR
Zha, 2020, 32652163	High	Bacterial	M. pneumoniae	Prevalence	NA	NR	Mild/Moderate /Non-ICU	22/22 (100)	NR
Zhu, 2020, 32408156	High	Bacterial	NR	Prevalence	NA	National Health Commission of the People's Republic of China version 5	Severe/Critical /ICU	16/17 (94.1)	NR
.	.	.	.	.	.	.	Mild/Moderate /Non-ICU	220/240 (91.7)	NR
Chen, 2020, 32405109	High	Fungal	NR	Prevalence	NA	Trial v7 Guidelines of China	Severe/Critical /ICU	6/51 (11.8)	NR
Salehi, 2020, 32609906	High	Fungal	Candida, C. albicans	Prevalence	NA	NR	Severe/Critical /ICU	26/53 (49.1)	NR
Wang, 2020, 32503617	High	Fungal	Aspergillosis	Prevalence	NA	NR	Severe/Critical /ICU	8/8 (100)	NR
Zhang, 2020, 32311650	High	Fungal	NR	Incidence	NR	International guidelines for community-acquired pneumonia	Severe/Critical /ICU	6/55 (10.9)	0.001
.	.	.	.	.	.	International guidelines for community-acquired pneumonia	Mild/Moderate /Non-ICU	1/166 (0.6)	

Zhu, 2020, 32408156	High	Fungal	NR	Prevalence	NA	NR	Severe/Critical /ICU	5/17 (29.4)	NR
							Mild/Moderate /Non-ICU	31/240 (12.9)	NR
Lendorf, 2020, 32800073	High	Bacterial or fungal	NR	Incidence	30 d	NR	Severe/Critical /ICU	12/91 (13)	NR
.	.	.	.	.	.	NR	Mild/Moderate /Non-ICU	2/20 (10)	NR
Lv, 2020, 32425649	High	Bacterial or fungal	A. baumannii, Staphylococcus haemolyticus, E. coli, Candida tropicalis, C. albicans, Pseudomonas aeruginosa Stenotrophomonas maltophilia, Enterococcus faecium, Candida parapsilosis, Candida lusitanae	Prevalence	NA	NR	Severe/Critical /ICU	19/32 (59.4)	NR
.	.	.	.	.	.	NR	Mild/Moderate /Non-ICU	1/8 (12.5)	NR
Zhu, 2020, 32408156	High	Bacterial or fungal	NR	Prevalence	NA	NR	Severe/Critical /ICU	5/17 (29.5)	NR
.	.	.	.	.	.	NR	Mild/Moderate /Non-ICU	56/240 (23.3)	NR

Abbreviations: C. pneumonia = Chlamydia pneumonia, E. Coli = Escherichia coli, ECMO = extracorporeal membrane oxygenation, d = days, ICU = intensive care unit, IQR = interquartile range, M. pneumoniae = Mycoplasma pneumoniae, NA = not applicable, NIV = non-invasive ventilation, NR = not reported, PMID = PubMed ID, RoB = risk of bias, unadj. = unadjusted, * = all study designs were single group and no study reported effect size estimates

Table 23. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Asthma)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with asthma	2/6 (33.3)
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	Patients with asthma	5/59 (8.5)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with asthma	0/46 (0)

Abbreviations: d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 24. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Chronic kidney disease [CKD])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	Patients with CKD	26/59 (44.1)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with CKD	10/46 (21.7)
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Patients with CKD	1/22 (4.5)
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with CKD	6/30 (20)
Salehi, 2020, 32609906	Single group	High	Fungal	Candida, C. albicans	Prevalence	NA	Patients with CKD	11/53 (20.8)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with CKD	2/8 (25)

Abbreviations: d = days, CKD = chronic kidney disease, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 25. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical exposure (Chronic obstructive pulmonary disorder [COPD])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)	Unadj. P Value
Ma, 2020, 32922049	Single group	High	Bacterial	Mycoplasma pneumoniae, Chlamydia pneumoniae	Incidence	14-28 d	Patients with COPD	1/21 (4.8)	
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	Patients with COPD	10/59 (16.9)	
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with COPD	6/46 (13)	
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Patients with COPD	1/22 (4.5)	
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with COPD	4/30 (13.3)	
van Arkel, 2020, 32396381	Single group	High	Fungal	Aspergillus fumigatus	Incidence	NR	Patients with COPD	2/6 (33.3)	
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with COPD	2/8 (25)	
Wu, 2020, 32642086	Cohort	Moderate	Bacterial or fungal	NR	Incidence	NR	Patients with COPD	10/50 (20)	<0.001
							Patients w/o COPD	59/998 (5.9)	

Abbreviations: COPD = chronic obstructive pulmonary disorder, d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias, Unadj. = unadjusted, w/o = without

Table 26. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Chronic pulmonary disease [CPD])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Dudoignon, 2020, 32544219	Single group	High	Bacterial	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	Incidence	5 d	Patients with CPD	2/20 (10)

Abbreviations: CPD = chronic pulmonary disease, d = days, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 27. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Coronary disease [CD])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Dudoignon, 2020, 32544219	Single group	High	Bacterial	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	Incidence	5 d	Patients with CD	1/20 (5)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence, coronary artery disease	NR	Patients with CD	1/6 (16.7)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with CD	10/46 (21.7)

Abbreviations: CD = coronary disease, d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 28. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Diabetes mellitus [DM])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Dudoignon, 2020, 32544219	Single group	High	Bacterial	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	Incidence	5 d	Patients with DM	8/20 (40)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with DM	2/6 (33.3)
Ma, 2020, 32922049	Single group	High	Bacterial	Mycoplasma pneumoniae, Chlamydia pneumoniae	Incidence	14-28 d	Patients with DM	2/21 (9.5)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with DM	24/46 (52)
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Patients with DM	5/22 (22.7)
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with DM	5/30 (16.7)
Nasir, 2020, 32585069	Single group	High	Fungal	Aspergillosis	Incidence	8 d	Patients with DM	8/9 (88.9)
Salehi, 2020, 32609906	Single group	High	Fungal	Candida, C. albicans	Prevalence	NA	Patients with DM	20/53 (37.7)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with DM	2/8 (25)

Abbreviations: d = days, DM = diabetes mellitus, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 29. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (End stage renal disease [ESRD])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with ESRD	1/6 (16.7)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with ESRD	2/46 (4)

Abbreviations: ESRD = end stage renal disease, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 30. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Heart failure [HF])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with HF	3/6 (50)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with HF	7/46 (15.2)
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Patients with HF	1/22 (4.5)

Abbreviations: HF = heart failure, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 31. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Hypertension [HTN])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Dudoignon, 2020, 32544219	Single group	High	Bacterial	Enterococcus faecium, Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenzae, Citrobacter koseri, Klebsiella aerogenes, Escherichia coli, Burkholderia sp., Pseudomonas aeruginosa, Stenotrophomonas maltophilia	Incidence	5 d	Patients with HTN	12/20 (60)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with HTN	5/6 (83.3)
Ma, 2020, 32922049	Single group	High	Bacterial	Mycoplasma pneumoniae, Chlamydia pneumoniae	Incidence	14-28 d	Patients with HTN	3/21 (14.3)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with HTN	36/46 (78.3)
Zha, 2020, 32652163	Single group	High	Bacterial	Mycoplasma pneumoniae	Prevalence	NA	Patients with HTN	4/22 (18.2)
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with HTN	16/30 (53.3)
Nasir, 2020, 32585069	Single group	High	Fungal	Aspergillosis	Incidence	8 d	Patients with HTN	5/9 (55.6)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with HTN	7/8 (87.5)

Abbreviations: d = days, HTN = hypertension, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 32. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Immunocompromised [IC])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)	Unadj. P Value
Rinaldi, 2020, 32779808	Cohort	High	Bacterial	NR	Incidence, SOT	30 d	IC	12/24 (50)	<0.001
							Not IC	130/861 (15.5)	
Vaughn, 2020, 32820807	Single group	High	Bacterial	NR	Incidence	7 d	IC	8/59 (13.6)	
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence, SOT	7 d	IC	1/30 (3.3)	
Rinaldi, 2020, 32779808	Cohort	High	Fungal	Pulmonary aspergillosis, invasive candidiasis	Incidence, SOT	30 d	IC	2/24 (8.3)	0.01
							Not IC	13/861 (1.5)	
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	IC	0/8 (0)	

Abbreviations: d = days, IC = immunocompromised, NA = not applicable, PMID = PubMed ID, RoB = risk of bias, SOT = solid organ transplant, unadj. = unadjusted

Table 33. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Malignancies)

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Gayam, 2020, 32449972	Single group	High	Bacterial	Mycoplasma pneumoniae	Incidence	NR	Patients with malignancies	1/6 (16.7)
Ma, 2020, 32922049	Single group	High	Bacterial	Mycoplasma pneumoniae, Chlamydia pneumoniae	Incidence	14-28 d	Patients with malignancies	1/21 (4.8)
Bartoletti, 2020, 32719848	Single group	High	Fungal	Pulmonary aspergillosis	Incidence	7 d	Patients with malignancies	2/30 (6.7)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with malignancies	0/8 (0)

Abbreviations: d = days, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

Table 34. Research Question 2: Risk factor of bacterial and/or fungal coinfections – Categorical outcome (Mechanical ventilation [MV])

Study, Year, PMID	Design	Overall RoB	Bacterial or Fungal	Type of pathogen	Outcome Measurement	Follow up	Arm	n/N (%)
Goncalves, 2020, 32808695	Single group	High	Bacterial	NR	Prevalence	NA	Patients with MV	20/46 (43.5)
Salehi, 2020, 32609906	Single group	High	Fungal	Candida, C. albicans	Prevalence	NA	Patients with MV	16/53 (30.2)
Wang, 2020, 32503617	Single group	High	Fungal	Invasive pulmonary aspergillosis	Prevalence	NA	Patients with MV	4/8 (50)

Abbreviations: MV = mechanical ventilation, NA = not applicable, NR = not reported, PMID = PubMed ID, RoB = risk of bias

