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COVID-19 Post-acute Care Major Organ Damage: A Living Rapid Review

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PREFACE

The VA Evidence Synthesis Program (ESP) was established in 2007 to provide timely and accurate syntheses of targeted healthcare topics of importance to clinicians, managers, and policymakers as they work to improve the health and healthcare of Veterans. These reports help:

- Develop clinical policies informed by evidence;
- Implement effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- Set the direction for future research to address gaps in clinical knowledge.

The program is comprised of three ESP Centers across the US and a Coordinating Center located in Portland, Oregon. Center Directors are VA clinicians and recognized leaders in the field of evidence synthesis with close ties to the AHRQ Evidence-based Practice Center Program and Cochrane Collaboration. The Coordinating Center was created to manage program operations, ensure methodological consistency and quality of products, and interface with stakeholders. To ensure responsiveness to the needs of decision-makers, the program is governed by a Steering Committee comprised of health system leadership and researchers. The program solicits nominations for review topics several times a year via the program website.

Comments on this report are welcome and can be sent to Nicole Floyd, Deputy Director, ESP Coordinating Center at Nicole.Floyd@va.gov.

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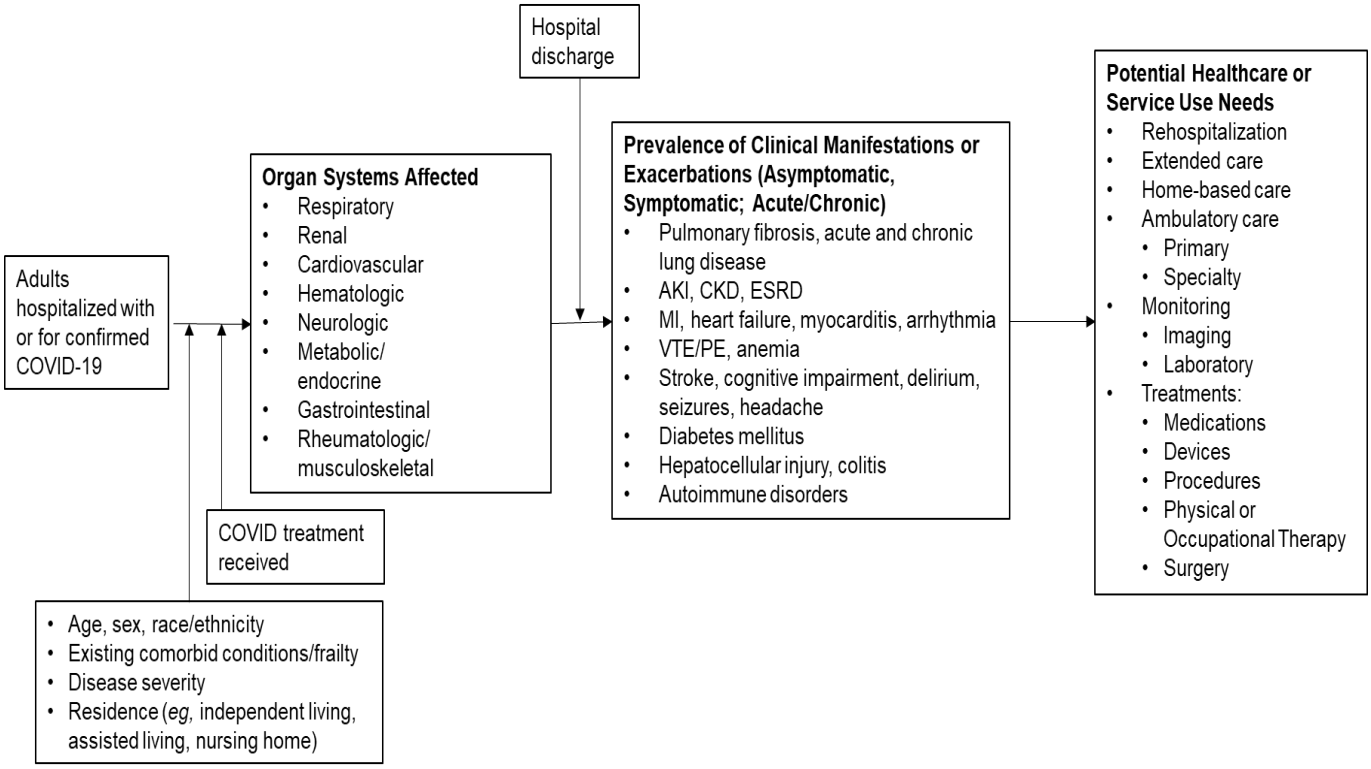
BACKGROUND

Coronavirus disease-2019 (COVID-19) is a viral illness that, as of December 1, 2020, was identified in over 62 million individuals (over 13 million in the US) in 220 countries, areas, or territories (https://www.who.int/emergencies/diseases/novel-coronavirus-2019, https://coronavirus.jhu.edu/, https://covid.cdc.gov/covid-data-tracker/#cases_casesper100klast7days). Over 1.4 million deaths worldwide (over 265,000 in the US) are attributed to COVID-19. COVID-19 is caused by the severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) and was declared a pandemic by the World Health Organization on March 11, 2020. In addition to the potential for severe pulmonary disease, there have been numerous reports of other major organ system manifestations and complications in patients hospitalized with COVID-19 including cardiovascular,[1,2] renal,[3,4] neurological,[5,6] hematologic,[7-9] endocrine,[10] and gastrointestinal.[11]

Persistent *symptoms* have been reported in patients following recovery from acute COVID-19 with fatigue, shortness of breath, muscle or body pain, and difficulty concentrating most common.[12-16] Multi-organ damage[17] and long-term clinical outcomes[18] following other coronavirus outbreaks – severe acute respiratory syndrome (SARS) and Middle East Respiratory syndrome (MERS) – have been reported, suggesting the potential for similar multi-organ damage and adverse long-term clinical outcomes with COVID-19 infections. In addition, because many COVID-19 patients are admitted to intensive care units, outcomes similar to those observed in post-intensive care syndrome or post-sepsis syndrome have also been suggested as possible long-term consequences of COVID-19 infections.[19]

The purpose of this living rapid review is to determine the prevalence of post-acute care major organ damage and healthcare or service use needs associated with major organ damage in adults who were hospitalized with or for COVID-19. The topic was nominated by the VA Evidence Synthesis Program Coordinating Center in collaboration with VHA clinical and operations partners in order to guide future clinical care decisions and resource needs related to COVID-19. It is 1 in a series of 3 living rapid reviews conducted across VA ESP sites addressing post-acute care prevalence related to: 1) mental health, 2) rehabilitation/functional status, and 3) major organ damage in patients hospitalized with or for COVID-19. Our analytic framework is shown in Figure 1.

Figure 1. Analytic Framework



KEY QUESTIONS AND SCOPE

1. What is the post- acute care prevalence of major organ damage among adults hospitalized with or for proven COVID-19 disease?

2. Does the post-acute care prevalence of major organ damage among adults with or for COVID-19 disease vary by patient characteristics (*eg,* age, sex, race/ethnicity, preexisting co-morbidities/frailty, place of residence), COVID-19 disease severity, or other factors (*eg*, treatment for COVID-19)?

3. What are the short- (< 3 months) and long-term (≥ 3 months) healthcare or service use needs of adults surviving COVID-19 disease with major organ damage?

In consultation with VHA central office operational partners, we included studies of adults hospitalized for COVID-19 and studies of adults hospitalized for another indication who have a positive COVID-19 test. Additionally, in collaboration with our local clinical content experts we prioritized conditions likely of greatest clinical relevance and included criteria for determining definitions and measures of symptomatic versus asymptomatic as well as acute versus chronic major organ damage. All patients had laboratory-confirmed COVID-19. We defined post-acute to include major organ damage or healthcare/service use needs reported on the day of hospital discharge or any time post-discharge. We included studies reporting "surrogate measures" (*eg*, a radiologic or laboratory measure consistent with a definition of a disease such as pulmonary function tests, radiographic pulmonary abnormalities, laboratory liver function tests or imaging

studies, creatinine, glucose or hemoglobin A1c values, cardiac imaging defined as abnormal or imaging studies for venous thromboembolism). We excluded studies reporting only mean or median values for these tests as mean or median values do not provide a reliable measure of organ damage prevalence or healthcare/service use. We also excluded studies reporting only general symptoms (*eg*, fatigue, pain), and did not extract these data from included studies because symptoms are not specific to a disease or organ damage. We included studies reporting on dyspnea as we determined dyspnea to be most consistent with pulmonary or cardiac damage. As noted above, post-acute mental health and functional status are addressed in separate ESP reviews. We excluded studies of children and studies of adults who had COVID-19 but were not hospitalized. We also excluded studies that did not provide information at the time of or after hospital discharge even if they included patient information during hospitalization.

METHODS

Our protocol was registered in PROSPERO: CRD42020204788.

SEARCH STRATEGY

We searched MEDLINE, Embase, and the Cochrane Library from January 1, 2019 to October 6, 2020. The search strategy (Appendix A) was developed with input from expert medical librarians. We also reviewed non-peer-reviewed public postings about post-COVID-19 complications for links to peer-reviewed data reports.

SCREENING PROCESS

Consistent with established rapid review methods, abstracts were reviewed by 1 investigator. A subset of 200 abstracts underwent dual independent review with substantial agreement between the 2 investigators. All articles identified as potentially eligible based on abstract review were independently reviewed by 2 investigators at the full-text level. Reasons for exclusion were noted. Conflicts were resolved by discussion. Our inclusion and exclusion criteria are reported in Table 1. We did not require studies to include a comparison group nor did we require that studies provide information about "preCOVID-19" health status/conditions or the primary reason for hospitalization (*ie, due to* COVID-19 compared to *for other conditions* where COVID-19 may be contributing factor or identified incidentally on screening).

DATA ABSTRACTION

Study characteristics (location, design, funding), study inclusion and exclusion criteria, baseline demographic data (age, sex, race, comorbidities), hospitalization characteristics (COVID-19 severity, ICU admission, mechanical ventilation, length of hospital stay), length of time post-hospital, and outcomes data were abstracted by 1 investigator and verified by a second. Discrepancies were resolved by discussion

RISK OF BIAS ASSESSMENT

We did not formally rate risk of bias. We assessed study quality characteristics using the Joanna Briggs Critical Appraisal Tool for case series[20] taking into account clarity of inclusion criteria

and completeness of inclusion, use of standard methods for identification and assessment of the condition, and inclusion of adequate information about the subjects and setting.

SYNTHESIS

Due to heterogeneity in study populations, study designs, and methods of outcome assessment, we were unable to pool outcomes data. We narratively synthesized the evidence.

Table 1. Study Eligibility Criteria

Study Characteristic	Include	Exclude
Population	Adults (age 18 and older)	Children or adolescents, age <18; MERS; SARS
Intervention	Discharge (or ready for discharge) from hospitalization after admission with or for proven COVID-19	Data collected from patients during ongoing hospital acute-care admission with or for proven COVID-19
Comparator	Discharge from hospitalization for individuals without COVID-19 (ideally another respiratory condition); a comparator was not required	None
Outcomes	Prevalence and severity of major organ damage (respiratory, renal, cardiovascular, hematologic, neurologic, metabolic/endocrine, gastrointestinal, and rheumatologic/musculoskeletal); healthcare or service use needs related to major organ damage	No outcomes of interest
Timing	Short-term (< 3 months) and long-term (≥ 3 months) post-discharge	None
Setting	Any post-discharge setting (*eg*, home, rehabilitation or long-term care facility); may include re-hospitalization	None
Study Designs	Cohort, case series, other observational; may prioritize articles using a best-evidence approach	Case report, narrative review, descriptive/opinion article with no data

LIVING REVIEW

We plan to update our literature search, using the search strategy outlined above, at least every 3 months through December 2021 for new evidence related to post-acute major organ damage and associated healthcare/service use needs. Study eligibility criteria, procedures for data abstraction, and risk of bias assessment will remain the same. Our data synthesis plan may change if future evidence allows. New evidence that does not substantially change review conclusions will be summarized every 3 months. New evidence that changes review conclusions or certainty of evidence will be incorporated into a major update.

PEER REVIEW

A draft version of this report underwent peer review by content experts and clinical leadership. Reviewer comments and our responses are presented in Appendix B and the final report incorporates these comments.

RESULTS

KEY FINDINGS

Key Question 1: Limited post-hospital data with wide ranging prevalence estimates that mainly rely on physiologic outcomes from convenience samples without controls; most not conducted in US.

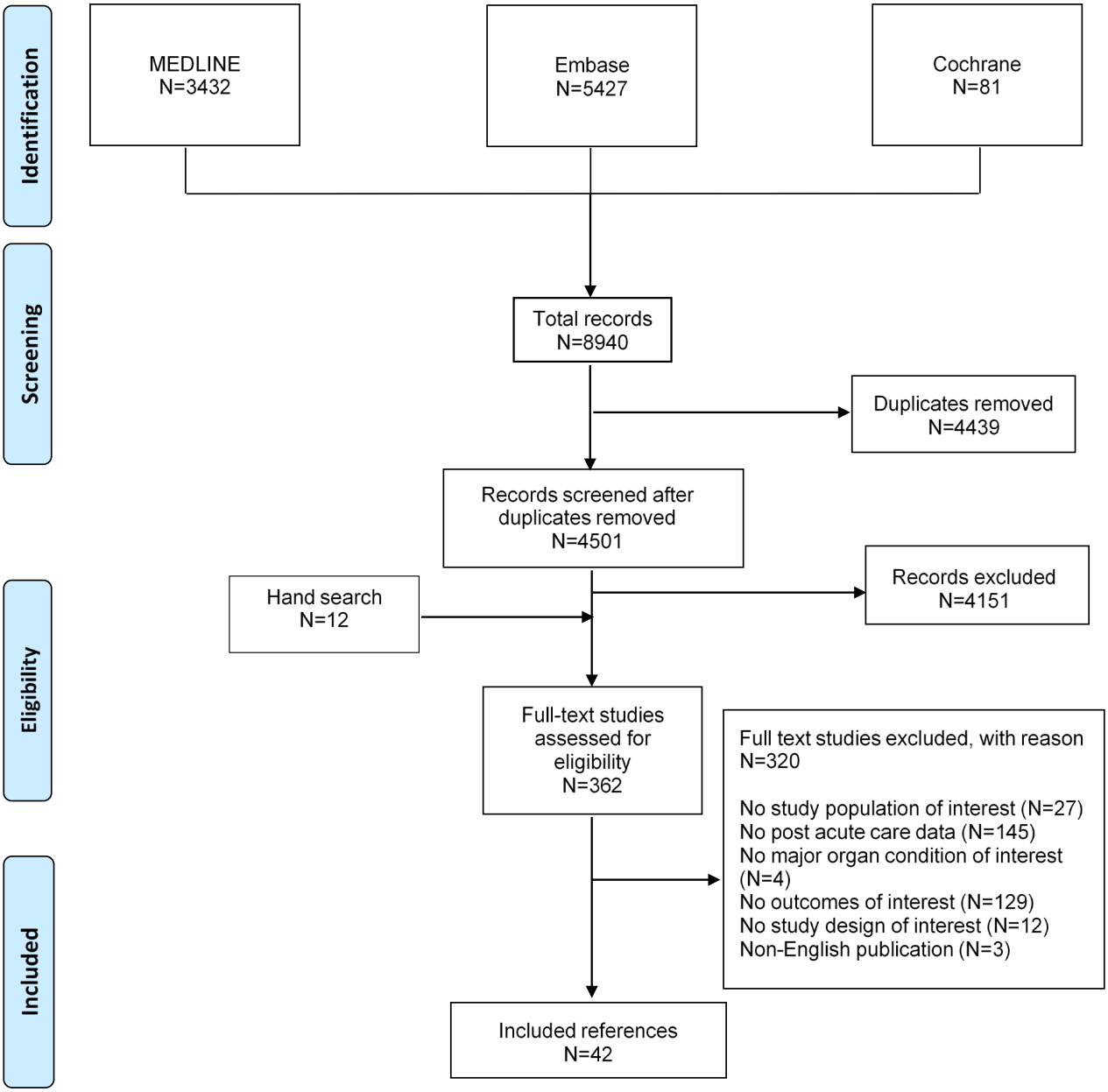
Key Question 2: Information is insufficient to assess if prevalence varies by patient, disease, and comorbidity factors.

Key Question 3: Little information on post-hospitalization resource use including discharge disposition and readmission.

PRISMA FLOW DIAGRAM

The results of our literature search and study selection process are depicted in Figure 2.

Figure 2. PRISMA Flow Diagram



OVERVIEW OF INCLUDED STUDIES

We identified 42 studies reporting outcomes data (Table 2) at the time of hospital discharge (k=17),[21-37] post-discharge (10 studies at 30 days or fewer follow-up) (k=22),[38-59] or both (k=3).[60-62]

Twelve studies reported pulmonary outcomes,[21,22,26,28,29,33,39,42,43,46,55,58,59] 6 reported neurological outcomes,[21,23,30,32,35,43] 4 studies reported cardiovascular outcomes,[22,39,45,49] 3 reported renal outcomes,[24,34,39] 3 reported hematologic outcomes,[22,48,51] 1 reported gastrointestinal outcomes,[39] and 22 reported healthcare or resource utilization outcomes.[25,27,30,31,36-38,40,41,44,47,48,50,52-57,60-62] Studies were typically described as retrospective, case series, or cross-sectional although 9 were described as prospective cohort studies.[21,22,37,39,40,43,49,51,55] We did not formally rate study risk of bias. Twenty-five of 42 studies enrolled all or consecutive patients, 18 were single-site studies, 18 provided little information about the group of patients discharged or the time of the follow-up with respect to the time of discharge, and many were unclear about data sources and completeness of follow-up. Study inclusion and exclusion criteria, patient demographics, and hospitalization characteristics are reported in Appendix C, Table 1; study quality assessments are reported in Appendix C, Table 2.

PULMONARY OUTCOMES

Of the 12 studies reporting pulmonary outcomes (Appendix C, Tables 1 and 3), 5 were from China,[33,46,55,58,59] 6 were from Europe,[26,28,29,39,42,43] and 1 was from the Middle East.[22] Sample sizes ranged from 18 to 131 with all but 5 studies enrolling 50 or fewer individuals. Mean or median ages ranged from 37 to 73 years and the percentage of males enrolled ranged from 35% to 84%. Seven studies reported hospital length of stay with mean or median values ranging from 10 to 28 days.[26,29,43,46,55,58,59] Eight studies reported ICU admission. One study excluded patients admitted to the ICU[33] and 2 enrolled only post-ICU patients.[22,26] In the other 5 studies, 3% to 31% were admitted to ICUs. One study excluded patients who received mechanical ventilation[33]; in the other 5 studies reporting, between 2% and 100% received mechanical ventilation. None of the studies included a comparison to non-COVID-19 patients. Reported outcomes varied across the studies with most reporting surrogate measures of health outcomes.

Table 2. Overview of Included Studies

Major "Organ" of Interest								
# Studies*	12	4	6	3	22	0	1	3
Location	China: 5 Europe: 6 Middle East: 1	China: 1 Europe: 2 Middle East: 1	Europe: 2 US: 2 Multiple: 2	US: 2 Europe: 1	China: 3 US: 13 Europe: 4	NA	Europe	US: 1 Europe: 1 Middle East: 1
Time of Assessment	Hospital DC: 4 Rehab Unit Admission: 1 Post-DC: 7	Hospital DC: 1 Post-DC: 3	Hospital DC: 5 Post DC: 1	Hospital DC: 2 Post DC: 1	Hospital DC: 6 Post-DC: 11 Hospital DC and post-DC: 5	NA	Post DC	Hospital DC: 1 Post DC: 2
Outcomes	Pulmonary fibrosis: 7 to 44%[46,58,59] Reduced Pulmonary function: 9 to 25%[33,46,58] Reduced DLCO:47 to 53%[33,42,46] Dyspnea: 100% (severe)[26]; 29% (mild to severe)[43] Other: PaO_2/FiO_2, respiratory support, impairment	Impaired EF: 11%[39] Pericardial effusion: 1.5% Ultrasound[22]; 20% CMR[49] LGE: 22 to 32%[45,49] Native T1, T2: elevated in COVID-19[45,49] Elevated hsTNT: 5%[49]	NIH Stroke scale: moderate symptoms[23,30] Modified Rankin Scale "moderate-to-severe" stroke sequelae: 29 to 83%[21,23,30,32,35]	AKD: 28 to 35%[24,34] Need for KRT: 31% survivors on KRT in hospital[34] Impairment imaging: 22%[39]	Positive SARS-CoV-2 (post DC): 9 to 63%[44,54,55,57,60] Readmission: 2 to 12%[38,40,41,47,48,50,52,53,55,60-62] Discharge: Home: 35 to 93%; Rehabilitation other care: 2 to 50%; Nursing home: 6 to 15%[25,27,30,31,36,37,50,55,60-62] Other: post-DC treatment	NA	Liver inflammation on imaging: 16%[39]	DVT: 12.5%[22] Thrombo-embolism: 0.5 to 2.5%[48,51] Hemorrhage: 3.7%[48]

AKD=acute kidney disease; CMR: cardiac magnetic resonance imaging; DC=discharge; DLCO=diffusing capacity for carbon dioxide; DVT=deep venous thrombosis; EF=ejection fraction; hsTNT=high-sensitivity Troponin; KRT=kidney replacement therapy; LGE=late gadolinium enhancement; MRI=magnetic resonance imaging; NA=not available (no studies reporting); US=United States

*Studies may appear in more than 1 column

Pulmonary; Cardiac; Neurologic; Renal; Resource Use; Musculoskeletal and Endocrine; Gastrointestinal; Hematologic

Radiographic Fibrosis

Three studies reported the percentage of patients with pulmonary fibrosis. One study defined fibrosis on CT chest imaging as a combination of findings including parenchymal bands, irregular interfaces, coarse reticular pattern, and traction bronchiectasis.[59] At a median of 8 days post-discharge, pulmonary fibrosis was identified in 44% (14/32).[59] The other 2 studies did not report how fibrosis was diagnosed. In 1 study, at 30 days post-discharge, 7% (4/57) had pulmonary fibrosis.[46] The other study, assessing outcomes at a mean of 38 days post-discharge, reported 22% (4/18) with pulmonary fibrosis and 61% (11/18) with ground-glass opacity plus pulmonary fibrosis.[58]

Pulmonary Function

Pulmonary function tests were also reported by 3 studies. The percentage of patients with forced expiratory volume in 1 second (FEV_1) less than 80% of predicted was 14% (15/110) in 1 study assessing lung volume at discharge[33] and 9% (5/57)[46] and 17% (3/18)[58] in 2 studies assessing lung volume at ≥30 days post-discharge. In the same studies, the percentage of patients with forced vital capacity (FVC) less than 80% of predicted was 9% (10/110) in the study assessing lung volume at discharge[33] and 11% (6/57)[46] and 17% (3/18)[58] in studies assessing lung volume at ≥30days. An FEV_1/FVC ratio of less than 80% at 30 days post-discharge was noted in 44% (25/57)[46] while a ratio of less than 70% was noted at discharge in 5% (5/110)[33] and at 38 days post-discharge in 17% (3/18).[58] For all 3 outcomes there were no significant differences between subgroups based on COVID-19 severity. Total lung capacity less than 80% of predicted was reported in 2 studies: 12% (7/57) in 1 study[46] and 25% (27/110) in the other.[33] Mo et al reported a significantly (P<.05) higher percentage of patients with TLC <80% predicted in the severe pneumonia subgroup (47%) than in the mild (17%) or pneumonia (21%) subgroups[33] while Huang et al reported no difference based on severity.[46]

Ventilation Impairment

Two studies, both assessing lung function at approximately 1 month post-discharge, characterized ventilation impairment as restrictive or obstructive. In 1 study, 11% (6/57) were characterized as having obstructive impairment, 12% (7/57) as restrictive impairment, and 4% (2/57) as combined obstructive and restrictive.[46] In the second study, 17% (3/18) had obstructive impairment and 17% (3/18) had restrictive impairment.[58] Another study, not yet peer-reviewed, measured lung impairment with MRI at a median of 105 days after a positive COVID-19 result.[39] Deep breathing fractional area change of <39% was observed in 47% (16/34) evaluated.

Diffusing Capacity

Diffusing capacity for carbon dioxide (DLCO) less than 80% of predicted was reported in 53% (30/57)[46] and 47% (51/110)[33] of patients. Both studies also reported significant differences in DLCO for subgroups based on severity. In 1 study, DLCO was less than 80% predicted in 77% (13/17) of the severe cases and 43% (17/40) of the non-severe cases (P=.02).[46] In the other study, DLCO was <80% predicted for 84% (16/19) of the severe pneumonia subgroup, 42% (28/67) of the pneumonia subgroup, and 29% (7/24) of the mild subgroup (P<.01 for the severe pneumonia subgroup vs the pneumonia subgroup or the mild subgroup).[33] Another study reported that 26% (13/50) had altered diffusion capacity only, 18% (9/50) had restriction with altered diffusion

capacity, 8% (4/50) had restriction only, and 48% (24/50) had a normal pulmonary function test.[42]

Dyspnea

Measures of dyspnea were reported in 3 studies. Two used a modified Medical Research Council measure. One reported that 13% (4/32) were Grade 4 and 88% (28/32) were Grade 5 at the time of admission to a rehabilitation unit.[26] Grade 4 indicates a need to stop for breath after 100 meters or a few minutes on level ground while Grade 5 indicates too breathless to leave the house, or breathless after undressing (https://mrc.ukri.org/research/facilities-and-resources-for-researchers/mrc-scales/mrc-dyspnoea-scale-mrc-breathlessness-scale/). The second reported 29% (35/120) were at Grade 2 or higher at a mean of 111 days post-discharge. Grade 2 is described as "walks slower than people of the same age because of dyspnea or has to stop for breath when walking at own pace".[43] The third study used the Borg scale and assessed dyspnea following the 6-minute walk test.[28] Values were generally less than 3 (*ie,* "moderate" dyspnea) on a 10 point scale. This study also reported the presence of exercise-induced hypoxia (defined as SpO_2 <90%) in 50% (13/26). Six of the patients underwent further testing and pulmonary embolism was confirmed in 67% (4/6).[28]

Other Outcomes

In 1 study of patients admitted to a rehabilitation unit, moderate alteration (values of 200-299 mmHg) in PaO_2/FiO_2 was observed in 38% (12/32) with severe (values <200 mmHg) alteration in 41% (13/32). Only 13% (4/32) did not require oxygen support.[26] Two studies reported findings from computed tomography (CT).[46,55] One reported residual abnormality on CT 30 days post-discharge in 54% (31/57), including 94% (16/17) in the severe subgroup and 38% (15/40) in the non-severe subgroup.[46] The other reported chest CT deterioration in 6% (2/36) at 1-2 weeks post-discharge but no deterioration in 54 patients evaluated with CT at 3-4 weeks.[55] Another study reported "lung abnormalities" (worsening or appearance of X-ray pulmonary infiltrates) in 85% (6/7) at the time of hospital discharge.[29] Patients in this study were all receiving maintenance hemodialysis at the time of hospitalization. Finally, 1 study used point of care ultrasound at discharge and observed pleural effusions in 1.5% (1/64).[22] At ICU admission, pleural effusions had been observed in 22.4% (20/89).

CARDIOVASCULAR OUTCOMES

Cardiovascular outcomes were reported in 4 studies (Appendix C, Tables 1 and 4) – 2 from Europe,[39,49] 1 from China,[45] and 1 from the Middle East.[22] Sample sizes range from 26 to 100, mean or median ages ranged from 38 to 50 years, and the percentage of males enrolled ranged from 38% to 84%. None of the studies reported hospital length of stay. Two studies included comparison groups.[45,49] All cardiovascular outcomes were based on imaging or laboratory assessments rather than clinical definitions or patient centered outcomes.

Two studies used cardiovascular magnetic resonance (CMR) imaging to assess myocardial injury. In a study from Germany, 100 patients were assessed at a median of 71 days following diagnosis.[49] Thirty-three had been hospitalized. The mean age of the patients was 49 years and 53% were male. Among the hospitalized patients, 2 underwent mechanical ventilation and 17 underwent non-invasive ventilation. The study also reported imaging findings for 50 healthy controls (age- and sex-matched, normotensive, taking no cardiac medications, with normal

cardiac volumes and function) and 57 risk factor-matched controls (matched for age, sex, hypertension, diabetes, smoking, known coronary artery disease, or comorbidities). From the CMR imaging, pericardial effusion (>10 mm) was observed in 20% (20/100) of the COVID-19 patients, 0% of the healthy controls, and 15% (9/57) of the risk factor-matched controls. The difference between the COVID-19 group and the other groups was statistically significant (P<.05). Late gadolinium enhancement (LGE), reflecting scarring, was observed in 32% (32/100) (myocardial) and 22% (22/100) (pericardial) of the COVID-19 group. Both were significantly more prevalent (P<.05) in the COVID-19 patients than in the healthy controls (0% for both measures) or the risk factor-matched controls (17% (9/57) with myocardial LGE and 15% (8/57) with pericardial LGE). Abnormal native T1 values were observed in 73% (73/100) of all COVID-19 patients with significantly higher values (P=.02) in those who had required hospitalization although the difference was characterized as small. Abnormal native T1 was reported in 6% (3/50) of the healthy controls and 40% (23/57) of the risk factor-matched controls (both P<.05 vs the COVID-19 group). Abnormal native T2 values were observed in 60% (60/100) of the COVID-19 group with no difference noted between hospitalized and non-hospitalized patients. The prevalences were 4% (2/50) and 9% (5/57) in the healthy controls and risk factor-matched groups, respectively (both P<.05 vs the COVID-19 group). T1 and T2 generally reflect myocardial inflammation. The second study, from China, evaluated 26 patients referred for CMR due to cardiac symptoms post-discharge.[45] Patients with a history of coronary artery disease or myocarditis were excluded. COVID-19 was reported as severe for 15% (4/26) and moderate for 85% (22/26). The study reported data from healthy controls (similar age and gender with no cardiovascular disease or systemic inflammation) who underwent CMR at the same hospital. CMR for the COVID-19 patients was completed at a median of 47 days after the onset of cardiac symptoms. Myocardial edema was noted in 54% (14/26). Of the 14 with edema, 50% (7/14) had positive LGE and 50% (7/14) had a small pericardial effusion. A total of 8 patients (1 without myocardial edema) had positive LGE. Native T1, T2, and extracellular volume (ECV) were significantly elevated in the recovered COVID-19 patients with positive CMR findings compared with the healthy controls.

The study from Germany also reported blood test results.[49] Detectable high sensitivity troponin T (hsTNT) was reported in 71% (71/100) of the COVID-19 group with significantly elevated hsTNT in 5% (5/100). There was no significant difference in mean hsTNT values between the hospitalized and non-hospitalized groups. The percentage of patients with detectable hsTNT was significantly higher (P<.05) in the COVID-19 group than the healthy controls (22% [11/50] or risk factor-matched controls (57% [31/57]).

A study from the United Kingdom, not yet peer-reviewed, reported left ventricular ejection fraction data for 37 previously hospitalized patients at a median of 105 days after COVID-19 diagnosis.[39] Definite impairment (<50%) was noted in 11% (4/37) and borderline impairment (50-55%) in 19% (7/27) while 70% (26/37) were normal (>55%). Evidence of myocarditis was noted in 11% (4/37).

A study from Saudi Arabia noted pericardial effusion on ultrasound at discharge in 1.5% (1/64 survivors) among 89 hospitalized with severe COVID-19.[22]

NEUROLOGICAL OUTCOMES

Six studies reported neurological outcomes (Appendix C, Tables 1 and 5).[21,23,30,32,35,43] Two were conducted in Europe,[23,43] 2 in the US,[30,32] and 2 in multiple nations.[21,35] Sample sizes ranged from 13 to 509, mean or median ages ranged from 58 to 76 years, and between 46% and 63% were male.

Modified Rankin Scale

Five studies reported modified Rankin Scale (mRS) results at the time of hospital discharge. An mRS score of 0 to 2 is considered a good outcome – individuals are "able to look after their own affairs without assistance". A multi-nation study enrolled patients who underwent mechanical thrombectomy following a stroke.[21] Symptomatic patients were tested for COVID-19. An mRS score of 0 to 2 was observed for 17% (2/12) in the COVID-19 group compared with 30% (94/316) in the non-COVID-19 group. The difference was not statistically significant (P=.52). A study from Italy reported outcomes for patients who had been admitted for acute cerebrovascular disease and tested positive for COVID-19.[23] An mRS score of 0-2 was noted for 26% (11/43) of the COVID-19 group and 71% (48/68) of the non-COVID-19 group (P<.001). A study from the US included 6 patients who were admitted for COVID-19 and subsequently experienced a stroke ('COVID' group) and 7 patients who were admitted for a stroke and subsequently diagnosed with COVID-19 ('neuro' group).[30] An mRS score of >2 (a 'poor' outcome) was reported for 77% overall (10/13), including 67% (4/6) in the 'COVID' group and 86% (6/7) in the 'neuro' group. In a control group of non-COVID-19 patients with stroke hospitalized during the same time period, a 'poor' outcome was noted in 47% (25/53) (P=.047 vs the overall study group). A second study from the US compared patients with and without neurological manifestations during hospitalization with COVID-19.[32] A history of neurological disorder was noted in 26% (134/509). An mRS score of 0 to 2 at discharge was reported for 71.4% (299/419) with neurological manifestations during hospitalization compared with 70.0% (63/90) with no neurological manifestations. Among patients with encephalopathy during hospitalization, 32,1% (52/162) had an mRS score of 0 to 2 compared with 89.3% (310/347) of those with no encephalopathy. Another multi-nation study reported severe disability in 51% (49 of 96 survivors).[35] The median [IQR] scores for the COVID-19 group and a propensity-matched group were 4 [2-6] and 2 [1-4], respectively (P<.001).

NIH Stroke Scale

Two studies reported NIH Stroke Scale scores.[23,30] Scores range from 0 (no symptoms) and 42 (severe symptoms) with scores between 1 and 4 indicating minor stroke symptoms and scores between 5 and 15 indicating moderate stroke symptoms (https://www.stroke.nih.gov/resources/scale.htm). The study from Italy reported median [IQR] scores of 9.0 [1.0-19.0] in the COVID-19 group and 2.0 [0.0-6.8] in the non-COVID-19 group (P=.005).[23] The study from the US reported median [IQR] scores of 11 [4-23] in the overall study group of 13 patients and 3 [2-13] in the non-COVID comparison group.[30]

RENAL OUTCOMES

Renal outcomes were reported by 3 studies (Appendix C, Tables 1 and 6), 2 from the US[24,34] and 1 from Europe.[39] The 2 studies from the US each reported on over 600 survivors while the study from Europe enrolled 37. Mean or median ages ranged from 50 to 71, with 38% to 79% male.

A study from the US reported acute kidney disease (AKD) at discharge in 25% (291/832).[24] Twenty-three percent were Stage 1, 6% Stage 2, and 6% Stage 3. AKD stages were defined according to Kidney Disease: Improving Global Outcomes (KDIGO) criteria. At a median follow-up of 21 days, data were available for n=77 with AKD at discharge. Of those, 36% (29/77) had recovered, 33% (25/77) were Stage 1, 13% (10/77) were Stage 2, and 18% (14/77) were Stage 3. Data were also available for n=135 who had recovered kidney function at discharge. Of those, 86% (116/135) remained recovered, 10% (14/135) had new Stage 1 AKD, 2% (3/135) had new Stage 2 AKD, and 2% (3/135) had new Stage 3 AKD.

The second study from the US reported on 3,854 individuals who developed AKI while hospitalized for COVID-19.[34] Among those who required renal replacement therapy (RRT) while hospitalized, 17% (108/638) survived. Of the survivors, 33% (36/108) had not recovered kidney function and 92% (33/36) required RRT at discharge. Authors reported that 58% (19/33) had underlying chronic kidney disease at hospital admission. Among those who did not require RRT while hospitalized, 52% (1663/3216) survived and 26% (430/1663) of those had not recovered kidney function. Need for post-discharge in this group was not reported.

The study from Europe, not peer-reviewed, reported an imaging finding at a median of 105 days post-COVID-19 diagnosis.[39] Definite impairment on kidney cortex T1 was observed in 22% (8/37) with normal findings in 78% (29/37).

GASTROINTESTINAL OUTCOMES

The European study, noted above and not peer-reviewed, also reported liver imaging findings (Appendix C, Tables 1 and 7).[39] At a median of 105 days post-COVID-19 diagnosis, liver inflammation (cT1 in ms) was normal (<800 ms) in 84% (31/37), borderline (800-825 ms) in 0% (0/37), and significant (>825 ms) in 16% (6/37).

HEMATOLOGIC OUTCOMES

Three studies reported hematologic outcomes (Appendix C, Tables 1 and 8).[22,48,51] A study from Saudi Arabia reported the incidence of deep venous thrombosis (DVT) at discharge (determined with ultrasound) was 12.5% (8/64 survivors). All patients in this study had been admitted to intensive care and received mechanical ventilation. The median age was 43 and 84% were male.

The other 2 studies reported outcomes post-discharge. In a study from the US, at a median of 23 days post-discharge, thromboembolism was observed in 2.5% (4/163).[48] Twenty-six percent (42/163) had been hospitalized in the ICU. Events included pulmonary embolism (PE), intracardiac thrombus, thrombosed arteriovenous fistula, and ischemic stroke. At a median of 27 days post-discharge, 3.7% (6/163) experienced hemorrhagic events. Two were considered ‘major bleeds”; both followed falls. Four were considered ‘clinically relevant non-major bleeding’. The patients experiencing thrombotic or hemorrhagic events had been discharged without anticoagulant therapy; among 13 patients discharged on thromboprophylaxis, there were no observed thrombotic or hemorrhagic complications.

A study from Europe reported venous thromboembolism (VTE) post-discharge.[51] Of 1877 included patients, 208 (11%) had been admitted to critical care. At a median of 8 days post-discharge, 0.48% (9/1877) experienced DVT (n=2) or PE (n=7). In a cohort of medical

admissions from 2019, 0.31% (56/18,159) experienced VTE events including 23 with DVT (8 proximal, 10 distal, and 5 line-associated upper-limb) and 33 with PE. The odds ratio for a VTE in the COVID-19 group was 1.6 (95%CI 0.77, 3.1) (P=.20).

HEALTHCARE/RESOURCE UTILIZATION OUTCOMES

Twenty-two studies – 13 from the US, 5 from China, and 4 from Europe – reported measures of healthcare and/or resource utilization (Appendix C, Tables 1 and 9).[25,27,30,31,36-38,40,41,44,47,48,50,52-57,60-62] Sample sizes ranged from 11 to 15,111 with 11 studies enrolling more than 100.[27,37,38,47,50,53,55,57,60-62] Mean or median ages ranged from 37 to 82; 1 study reported the range of ages (18 to 85).[36] Between 27% and 71% were male. COVID-19 severity was reported in 7 studies; 2 only enrolled severe[47] or critically ill[56] patients. Median hospital length of stay ranged from 2 to 24 days.)

Discharge Disposition

Eleven studies reported on discharge disposition.[25,27,30,31,36,37,50,55,60-62] Three studies enrolled patients with stroke or other neurological conditions.[30,31,36] One US study of patients who experienced a stroke reported that 30% (3/10) were discharged home (including 2 of 6 hospitalized for COVID-19 who subsequently experienced a stroke [‘COVID’] and 1 of 4 hospitalized for stroke symptoms who subsequently tested positive for COVID-19 [‘Neuro’]), 50% (5/10) were discharged to acute rehabilitation (3 of 6 in ‘COVID’ group, 2 of 4 in ‘Neuro’ group), and 20% (2/10) were discharged to long-term acute care (1 of 6 in “COVID’ group and 1 of 4 in ‘Neuro’ group).[30] Another US study of stroke patients (some had stroke onset during COVID-19 hospitalization and some had COVID-19 onset within 14 days of stroke onset) reported that 45% (25/56 discharged) were discharged home and 55% (31/56) to rehabilitation.[31] An additional 30 patients had died or were in hospice care (data not reported separately for deaths and hospice). In a comparison group of non-COVID-19 stroke patients, 52% (228/438 discharged) were discharged home and 48% (210/438) to rehabilitation. An additional 61 patients had died or were in hospice care.[31] The third study, from the United Kingdom, reported that, of COVID-19 neurological patients discharged, 56% (9/16) went home and 31% (5/16) went to a rehabilitation or stroke unit; the location of 13% (2/16) was not reported.[36]

One US study enrolled 20 patients with HIV who were hospitalized for COVID-19; 4 patients (20%) were from a VA Medical Center.[25] Of patients discharged, 81% (13/16) were discharged home, 6% (1/6) to a nursing facility (permanent residence), and 13% (2/16) to a hotel for those with confirmed COVID-19. Five of the 20 patients enrolled had been living in a group living situation prior to hospitalization (3 in nursing homes, 1 incarcerated, 1 in a substance abuse recovery home).

Another study from the US included 2 comparison groups: patients negative for COVID-19 and a historical control group.[27] Among those who tested positive for COVID-19 and were discharged, 77% (1650/2142) were discharged home and 23% to a nursing home (492/2142). Among patients negative for COVID-19 and discharged, 83% were discharged home (788/950) and 17% (162/950) to a nursing home. In the historical control group, 85% (8108/9544) were discharged home and 15% (1436/9544) to a nursing home. It was noted that 16% of patients were nursing home residents prior to hospitalization.

Two US studies provided data for subgroups based on treatment location[62] or age.[50] In the first study, of patients treated in the general practice unit and with known discharge disposition, 96% (183/191) went home and 4% (8/191) went to a rehabilitation center.[62] Of patients treated in the ICU and with known discharge disposition, 79% (49/62) went home and 21% (13/62) went to a rehabilitation center. In the second study, 6% (122/2081) of patients discharged alive were discharged to a "facility" (*eg*, nursing home, rehabilitation).[50] The total included 0% (0/32) of those under 18 years, 2% (28/1,373) of those 18 to 65 years, and 14% (94/676) of those over age 65. Ninety-four percent (1959/2081) were discharged home.

Two studies from the United Kingdom with similar patient demographics and hospital lengths of stay reported that 81.0% (56/69)[61] and 93% (614/664)[37] of patients discharged were discharged to home; and 14.0% (10/69)[61] and 5.1% (34/664)[37] were discharged to care homes. In 1 study, it was reported that 7.2% (5/69) were new care home placements.[61]

A study from China provided information at up to 4 weeks post-discharge.[55] At 1-2 weeks post-discharge, 87% (114/131) were in home quarantine, 9% (12/131) in community quarantine, 4% (5/131) in a "designated hospital", and 0% had returned to work. At. 3-4 weeks post-discharge, the values were 92% (121/131), 3% (4/131), 2% (3/131), and 2% (3/131), respectively.

One US study reported discharge disposition for patients who had been readmitted.[60] Of 19 readmitted, 5 (26%) were discharged to a skilled nursing facility and 14 (74%) either to home or a hotel for homeless persons experiencing COVID-19.

Hospital Readmission

Hospital readmission for any reason was reported by 12 studies.[38,40,41,47,48,50,52,53,55,60-62] Mean or median duration of follow-up to assess readmission ranged from 3 to 40 days; several studies did not report length of follow-up. The 2 largest studies were from Spain[38] and the US.[53] In the study from Spain, 4.8% (573/11,928) were readmitted.[38] Median follow-up was 40 days post-discharge. Over 5% (31/573) of readmitted patients remained hospitalized through the follow-up period. Reason for readmission was not provided. In the US study, with a 14 day follow-up, 3.6% (103/2864) returned for emergency care.[53] Of those, 54.4% (56/103) were admitted. The most frequently reported reasons for readmission included respiratory distress (60%), chest pain (6%), other pain (6%), altered mental status (5%), fall (5%), and soft tissue infection (5%). ICU-level care was required for 10.7% (6/56).

Comparison groups were included in 2 studies from the US.[40,41] In the first study, enrolling patients undergoing surgery for hip fracture, within 30 days of discharge, 11.8% (2/17) of COVID-19 positive patients had been readmitted compared with 2.8% (3/107) COVID-19 negative patients.[40] In the second study, 11% (9/92) patients were readmitted in both the COVID-19 acute respiratory distress syndrome (ARDS) group and a propensity match group with non-COVID-19 ARDS.[41] The length of follow-up post-discharge and reasons for readmission were not reported.

Another US study enrolled patients with severe ARDS.[47] Readmission rates ranged from 5 to 10% with no difference between those who also had asthma and those who did not in either the 21 to 39 year age group or the 40 to 65 year age group. Length of follow-up was not reported.

Readmission rates in different age groups were also reported in another US study.[50] After a median follow-up of 4.4 days, a total of 2.2% (45/2081) were readmitted including 3% (1/32) of those under 18 years, 2% (22/1,373) of those 18 to 65 years, and 3% (22/676) of those over age 65. The median time to readmission was 3 days.

Suleyman et al, a US study, reported 30-day hospital readmission was 11% (29 patients).[62] This included 27 patients who had been treated in the general practice unit and 2 patients treated in the ICU.

In 5 other studies, readmission rates ranged from 4% to 9%.[48,52,55,60,61] Three of the studies were from the US, 1 from the United Kingdom, and 1 from China. One of the US studies reported reasons for readmission.[60] Bacterial pneumonia secondary to COVID-19 was documented in 21% (4/19), a prolonged COVID-19 course in 21% (4/19), psychiatric episodes in 16% (3/19), metabolic encephalopathy in 11% (2/19), and thrombotic episodes in 11% (2/19).

Positive SARS-CoV-2 Post-Discharge

Five studies reported on patients with positive tests for SARS-CoV-2 following hospital discharge.[44,54,55,57,60] One US study, reported that 63% (12/19) tested positive at the time of readmission.[60] The remaining studies were from China.[44,54,55,57] In 1 of the studies, patients were isolated and monitored for 28 days post-discharge.[54] Another required 14 days quarantine and requested hospital visits every 2-4 weeks.[57] The third asked patients to follow-up every 7 days for 4 weeks.[55] The fourth included 2-4 week follow-up to assess short-term outcomes post-discharge.[44] Positive tests were reported in 2% to 28% of patients at follow-up times to 4 weeks post-discharge.

Post-discharge Treatment

Use of oxygen therapy ranged from 6% to 7% in 2 studies reporting. One study reported that 6% (5/85) were receiving oxygen therapy via nasal cannula at home (time post-discharge not specified).[56] Wang et al reported that at 1-2 weeks after discharge 7% (9/131) were treated with oxygen therapy.[55] At 3-4 weeks, the percentage decreased to 1% (1/131). Corticosteroid use was 4% (5/131) at 1-2 weeks and 2% (2/131) at 3-4 weeks.

A US study reported need for post-acute rehabilitation in patients undergoing surgery for hip fracture.[40] Ninety percent (9/17) of the COVID-19 group was receiving rehabilitation compared with 78.3% (83/107) of patients negative for COVID-19. The difference was not statistically significant (P=.61).

In a study from the United Kingdom, new “packages of care” were required for 2.9% (2/69) of patients discharged and an increase in mobility aids was noted for 11.6% (8/69).[61]

DISCUSSION

Our review identified 42 reports of post-acute major organ damage or healthcare/service use outcomes in patients who were hospitalized with or for COVID-19. Eighteen studies were from the US; 1 multisite US study included patients from a VA Medical Center. The amount of data is increasing rapidly. We identified an additional 25 studies in the 2.5-month interval from our

original July search date. Future updates are likely to identify relevant new data. We provide "Key Findings", "Limitation", and "Suggestions for Future Research".

KEY FINDINGS

Key Question 1

We identified limited published *post-hospital* data on conditions reported to be associated with COVID-19 during hospitalization including pulmonary, cardiovascular, gastrointestinal, hematologic/thrombotic, neurologic, or renal. Available evidence suggests:

- Pulmonary fibrosis in 7% to 44%, pulmonary function below thresholds in 9% to 25%, and diffusing capacity for carbon dioxide "altered" or below threshold in 47% to 53%,
- Impaired cardiovascular ejection fraction in 11% and LGE abnormalities in 22% to 32%,
- Moderate-to-severe stroke sequelae in 29% to 83%,
- Thromboembolism in 0.5% to 12.5%, and
- AKD in 28% to 35%.

We found no published *post-hospital* information for metabolic/endocrine or rheumatologic/musculoskeletal conditions.

Key Question 2

We are unable to determine if post-acute care prevalence of major organ damage varies by patient characteristics (*eg,* age, sex, race/ethnicity, pre-existing comorbidities/frailty, type of residence), COVID-19 disease severity, or other factors (*eg,* treatment for COVID-19). Few studies reported outcomes for subgroups of patients.

Key Question 3

Discharge disposition (other than home: 7% to 65%) and readmission (2% to 12%) were frequently reported outcomes. There was little or no information about other healthcare/resource use outcomes including post-hospital need for ambulatory care, imaging or laboratory monitoring needed, or treatments (*ie,* medications, devices, procedures, surgery) required.

LIMITATIONS

Additional limitations of the available evidence include:

- Available data are from studies of small, convenience samples (often from a single hospital site) with poorly described study populations or measures of major organ damage; 11 studies included control groups for comparison of COVID-19 and non-COVID-19 patients.
- Major organ damage measures were not standardized and varied considerably across studies. Reported prevalence rates are likely highly dependent on the measures used to assess and define major organ damage as well as the population being evaluated.

- Most studies assessed outcomes at discharge or had short follow-up post-discharge; long-term major organ damage prevalence and healthcare/service use needs are unknown.
- The contribution of comorbidities (prior to COVID-19 infection) to post-acute prevalence cannot be determined.

Limitations of our review methods include:

- We defined "post-acute COVID" as patients being post-hospital discharge. The applicability of these findings to non-hospitalized patients with acute COVID symptoms is unknown; this was out of our scope.
- Our literature search was through October 6, 2020 and would not have included information published after that date. Ongoing living review rapid review methods are needed to capture additional information.

FUTURE RESEARCH

Given the gaps in, and limitations of, the existing evidence, we suggest the following as a guide for future research to better inform healthcare systems as they plan for on-going care of patients recovering from COVID-19.

Population

We chose to define post-acute as post-hospitalization but other definitions may be appropriate. For example, patients with acute COVID-19 who are not hospitalized may have "post-acute" major organ damage. Limiting the scope of this review to patients hospitalized for acute COVID likely underestimates the total burden of post-acute major organ damage. This should be acknowledged for resource allocation planning in the future. Furthermore, we did not identify studies that assessed "long-haulers" or "long COVID" (*ie,* people who have either recovered from COVID-19 but still report lasting effects or who have had the usual symptoms for longer than might be expected).[63] This is a poorly defined entity and no published data were available. Additionally, there are likely important difference in patients hospitalized *for* COVID-19 versus patients hospitalized for another indication who have a positive COVID-19 test.. We chose to include both but this could influence prevalence, severity, and causality of findings. We also limited eligibility to studies that assessed patients with "confirmed" COVID-19. While this increases the specificity and accuracy of our review it also likely underestimates the burden of post-acute complications when also including patients with suspected COVID-19. Future studies should include all patients or consecutive patients rather than convenience samples. Study populations should be carefully described including severity of disease and treatments received. Results should be reported for subgroups based on age, gender, race/ethnicity, pre-existing conditions/frailty, type of residence (*eg,* independent living, assisted living, nursing home), COVID-19 severity, and treatment received. Ideally, researchers would be able to link pre-COVID-19 data with post-COVID-19 data. Without pre- and post- data, it is difficult to isolate the effects of COVID-19.

Comparator

The use of matched non-COVID-19 control groups would allow for a better understanding of the effects of COVID-19. Without appropriate comparators and information on pre-COVID conditions it is not possible to accurately determine the effect that COVID-19 has on post-acute health outcomes or the incremental effects versus controls without COVID-19. Nonetheless, given ongoing health and health care concerns associated with COVID-19, uncontrolled reports among patients with COVID-19 are still informative for care planning.

Outcomes

Many studies, excluded from our review, reported mean and median values of laboratory, radiologic, or physiologic measures. These data do not provide prevalence outcomes. Future research should include measures that will reflect prevalence of major organ damage or disease based on accepted definitions of disease, even if defined as asymptomatic laboratory, radiologic, or physiologic measures. Although many conditions have been reported to be associated with COVID-19 while patients are hospitalized, there has been little or no published post-hospital data for most of those conditions. Many reports were convenience samples and used testing measures available at that facility or selected for reporting for unclear reasons. Criteria for outcome assessment, reporting and definition will have important implications on major organ damage prevalence and severity.

Timing

Future research should include standardized and longer follow-up.

Setting

Information on major organ damage prevalence and healthcare/service use needs of non-hospitalized patients is also needed.

ONGOING DATA COLLECTION

We are aware of several ongoing studies:

- A study of COVID-19 sequelae among Veterans treated in the VA (https://www.hsrd.research.va.gov/research/abstracts.cfm?Project_ID=2141707422),
- A natural history study of COVID-19 titled "Epidemiology, Immunology and Clinical Characteristics of Emerging Infectious Diseases with Pandemic Potential" (EPICC-EID); a collaboration between the VA and the Department of Defense to better understand the clinical course of COVID-19 (https://www.research.va.gov/covid-19.cfm)
- Aa study sponsored by UK-based Perspectum Diagnostics (https://www.bioworld.com/articles/434620-perspectum-launches-study-of-post-covid-19-organ-damage),
- The Post-hospital COVID (PHOSP-COVID) study.[63]

- A multicenter observational registry, the North American COVID-19 ST-Segment-Elevation Myocardial Infarction (NACMI) registry, to collect data on ST elevation in COVID-19 patients to determine the etiology and associated clinical outcomes.[64]

Several major healthcare systems have established multidisciplinary post-COVID care clinics including the Mount Sinai (New York) Center for Post-COVID Care, the Penn Medicine Post-COVID Recovery Clinic, University of California San Francisco's OPTIMAL Clinic, the University of Michigan's Post ICU Longitudinal Survivor Experience (PULSE) Clinic (now focused on post-COVID-19), and the Mayo Clinic COVID Activity Rehabilitation Program (CARP). Anticipated post-acute care rehabilitation needs of patients and guidance on how to address those needs have been reported.[65-74] There is an emphasis on multi-disciplinary programs to address respiratory, cardiovascular, thromboembolism, and neurological sequelae along with physical function and mental health needs. Patient groups have also been organized with a focus on long-term symptoms. These include Survivor Corps (https://www.survivorcorps.com/) and the COVID-19 "Long Hauler" Symptoms Survey,[15] the Body Politic COVID-19 support group (https://www.wearebodypolitic.com/covid19), Long Covid SOS in the UK (www.longcovidsos.org), and the COVID Symptom Study with an app to study symptoms and track the spread of the virus (https://covid.joinzoe.com/us-2).

CONCLUSIONS

Our systematic review of the literature yielded limited early published data on post-acute COVID-19 major organ damage and healthcare/service use needs. The majority of studies were from outside the United States; only 1 study enrolled patients from a VA Medical Center. There was little information on patient-centered, clinical health outcomes. Available data are from studies of convenience samples with poorly described study populations and primarily physiologic outcomes; few included control groups for comparison of COVID-19 and non-COVID-19 patients. Studies of pulmonary function were most common and, although there were reports of pulmonary fibrosis, imaging abnormalities, and reduced pulmonary function, interpretation is difficult due to the absence of pre-COVID-19 data. Future research should attempt to include clear descriptions of the patient populations and the timing of outcome assessment with respect to hospitalization, link pre-COVID-19 data with post-COVID-19 data, and assess outcomes that allow for determination of prevalence of major organ damage and healthcare/service use needs.

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In designing the study questions and methodology at the outset of this report, the ESP consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicting opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

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Operational Partners

Operational partners are system-level stakeholders who have requested the report to inform decision-making. They recommend Technical Expert Panel (TEP) participants; assure VA relevance; help develop and approve final project scope and timeframe for completion; provide feedback on draft report; and provide consultation on strategies for dissemination of the report to field and relevant groups.

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APPENDIX A. SEARCH STRATEGIES

MEDLINE/EMBASE

1 (coronavir* or corona virus* or betacoronavir* or covid19 or covid 19 or nCoV or CoV 2 or CoV2 or sarscov2 **SARS 2 or SARS-CoV-2** or 2019nCoV or 2019 novel coronavirus* or 2019 novel CoV or wuhan virus* or ((wuhan or hubei or huanan) and (severe acute respiratory or pneumonia*))).ti,ab,kw.
2 Coronavirus Infections/ or Coronavirus/ or betacoronavirus/
3 1 or 2
4 Pulmonary fibrosis.ti,ab,kw. or exp Pulmonary Fibrosis/
5 exp Lung Diseases, Obstructive/
6 4 or 5
7 acute kidney injury.ti,ab,kw. or exp Acute Kidney Injury/
8 exp Renal Insufficiency, Chronic/
9 (end stage renal disease or ESRD or AKI or CKD).ti,ab,kw.
10 7 or 8 or 9
11 myocardial infarction.ti,ab,kw. or exp Myocardial Infarction/
12 (heart attack or heart failure or MI).ti,ab,kw.
13 myocarditis.ti,ab,kw. or exp Myocarditis/
14 exp Arrhythmias, Cardiac/
15 arrhythmia*.ti,ab,kw.
16 11 or 12 or 14 or 14 or 15
17 exp Venous Thrombosis/
18 exp Pulmonary Embolism/ or exp Venous Thromboembolism/
19 (deep ve* thrombosis or DVT or pulmonary embolism or PE).ti,ab,kw.
20 anemia.ti,ab,kw. or exp Anemia/
21 17 or 18 or 19 or 20
22 stroke.ti,ab,kw. or exp Stroke/
23 exp Cognitive Dysfunction/
24 exp Confusion/
25 exp Seizures/
26 exp Headache/
27 (stroke* or cerebrovascular accident* or cognitive impairment or cognitive dysfunction or delirium or confusion or seizure* or headache*).ti,ab,kw.
28 22 or 23 or 24 or 25 or 26 or 27
29 exp Diabetes Mellitus/
30 diabetes.ti,ab,kw.
31 29 or 30
32 exp Hepatitis/
33 exp Colitis/
34 (hepatitis or hepatocellular injur* or colitis).ti,ab,kw.
35 32 or 33 or 34
36 "Autoimmune Diseases of the Nervous System"/
37 autoimmune disease*.ti,ab,kw.
38 Musculoskeletal Diseases/
39 musculoskeletal.ti,ab,kw.
40 36 or 37 or 38 or 39
41 6 or 10 or 16 or 21 or 28 or 31 or 35 or 40
42 exp Hospitalization/ or exp Intensive Care Units/ or Inpatients/ or Subacute Care/
43 (hospital or hospitalized or hospitalization or intensive or ICU or care or post?acute or inpatient or inpatients or admit or admitted or admitting).ti,ab,kw.
44 42 or 43
45 3 and 41 and 44
46 limit 45 to english language
47 limit 46 to yr="2019 -Current"

COCHRANE LIBRARY

1 MeSH descriptor: [Coronavirus] explode all trees
2 (coronavirus):ti,ab,kw
3 (betacoronavirus):ti,ab,kw
4 (covid19):ti,ab,kw
5 (covid 19):ti,ab,kw
6 (nCoV):ti,ab,kw
7 (CoV2):ti,ab,kw
8 (CoV2):ti,ab,kw
9 (OR #1-#8)
10 ("pulmonary fibrosis"):ti,ab,kw
11 MeSH descriptor: [Pulmonary Fibrosis] this term only
12 MeSH descriptor: [Lung Diseases, Obstructive] explode all trees
13 (acute kidney injury):ti,ab,kw
14 MeSH descriptor: [Acute Kidney Injury] this term only
15 MeSH descriptor: [Renal Insufficiency, Chronic] this term only
16 ("end stage renal disease"):ti,ab,kw
17 (ESRD):ti,ab,kw
18 (AKI):ti,ab,kw
19 (CKD):ti,ab,kw
20 ("myocardial infarction"):ti,ab,kw
21 MeSH descriptor: [Myocardial Infarction] this term only
22 ("heart attack"):ti,ab,kw
23 ("heart failure"):ti,ab,kw
24 (myocarditis):ti,ab,kw
25 MeSH descriptor: [Myocarditis] this term only
26 (arrhythmia*):ti,ab,kw
27 MeSH descriptor: [Arrhythmias, Cardiac] this term only
28 MeSH descriptor: [Venous Thrombosis] this term only
29 MeSH descriptor: [Pulmonary Embolism] this term only
30 MeSH descriptor: [Venous Thromboembolism] this term only
31 ("deep venous thrombosis"):ti,ab,kw
32 ("pulmonary embolism"):ti,ab,kw
33 (anemia):ti,ab,kw
34 MeSH descriptor: [Anemia] this term only
35 MeSH descriptor: [Stroke] this term only
36 MeSH descriptor: [Cognitive Dysfunction] this term only
37 MeSH descriptor: [Confusion] this term only
38 MeSH descriptor: [Seizures] this term only
39 MeSH descriptor: [Headache] this term only
40 (stroke*):ti,ab,kw
41 ("cerebrovascular accident"):ti,ab,kw
42 ("cognitive impairment"):ti,ab,kw
43 ("Cognitive dysfunction"):ti,ab,kw
44 (delirium):ti,ab,kw
45 (confusion):ti,ab,kw
46 (seizure*):ti,ab,kw
47 (Headache*):ti,ab,kw
48 (diabetes):ti,ab,kw
49 MeSH descriptor: [Diabetes Mellitus] this term only
50 MeSH descriptor: [Hepatitis] this term only
51 MeSH descriptor: [Colitis] this term only
52 (hepatitis):ti,ab,kw
53 ("hepatocellular injur*"):ti,ab,kw
54 (colitis):ti,ab,kw
55 MeSH descriptor: [Autoimmune Diseases of the Nervous System] this term only

56 ("autoimmune disease"):ti,ab,kw
57 MeSH descriptor: [Musculoskeletal Diseases] this term only
58 (musculoskeletal):ti,ab,kw
59 (OR #10-#58)
60 (hospitalized):ti,ab,kw
61 (hospital):ti,ab,kw
62 (hospitalization):ti,ab,kw
63 ("intensive care"):ti,ab,kw
64 (ICU):ti,ab,kw
65 (Post-acute):ti,ab,kw
66 (Post acute):ti,ab,kw
67 (inpatient*):ti,ab,kw
68 (admit*):ti,ab,kw
69 MeSH descriptor: [Hospitalization] explode all trees
70 MeSH descriptor: [Intensive Care Units] this term only
71 MeSH descriptor: [Inpatients] this term only
72 MeSH descriptor: [Subacute Care] this term only
73 (OR #60-#72)
74 #9 AND #59 AND #73

APPENDIX B. PEER REVIEWER COMMENTS AND RESPONSES

Question Text	Comment	Response
Are the objectives, scope, and methods for this review clearly described?	Yes	Thank you
	Yes	
	Yes	
	Yes	
	Yes	
Is there any indication of bias in our synthesis of the evidence?	No	Thank you
	No	
	No	
	No	
	No	
Are there any published or unpublished studies that we may have overlooked?	No	Thank you
	No	
	No	
	No	
	No	
Additional suggestions or comments can be provided below. If applicable, please indicate the page and line numbers from the draft report.	Comments: - We note that this is one of a series of 3 rapid reviews by VA-ESP addressing post-acute care. One of the other reviews addresses rehab/functional status. This review focuses on major organ damage. The review that focuses on rehab/functional status is likely to be of particular interest to GEC. - This review sets out in detail the thorough steps taken to define the topics of interest, in consultation with appropriate operational leadership and SMEs. The search strategy and steps to narrow down to the final set of papers for full review are clearly laid out an appear (without reading all the papers) to be appropriate and well done. - The authors set out a good set of Key Questions, as follows: - The key questions from start of report:	Thank you.

Question Text	Comment	Response
	o 1. What is the post- acute care prevalence of major organ damage among adults hospitalized with or for proven COVID-19 disease? o 2. Does the post-acute care prevalence of major organ damage among adults with or for COVID-19 disease vary by patient characteristics (age, sex, race/ethnicity, preexisting co-morbidities, etc.), COVID-19 disease severity, or other factors (eg, treatment for COVID-19)? o 3. What are the short (< 3 months) and long-term (≥ 3 months) healthcare or service use needs of adults surviving COVID-19 disease with major organ damage? - The flow diagram shows: Identified 2954 records from databases. Narrowed down to 17 references that had information meeting the criteria for inclusion. This is a type of narrowing down often seen in evidence reviews. Even with the relatively liberal set of inclusion criteria, in order to cast a wide net in search of answers to the Key Questions, only 17 references met the criteria, which is the state of the literature (not surprisingly given the timing). - For characteristics that are desirable to include but which are not addressed in publication, would it be possible to include in the report a statement about what is missing (to provide encouragement for the field to consider in future papers)? - There is a plan to update periodically, which is good, given the rapidly evolving knowledge of COVID-19 - The age ranges are reported; however there is relatively little information about older adults specifically. Since COVID-19 has a markedly higher rate among older adults it would be helpful if whatever data are available from the literature on older adults could be called out separately. o Residents in skilled nursing facilities (SNF) account for a very substantial portion of the overall affected deaths of patients with COVID-19. It would be helpful if the review could call out separately any information about patients from SNFs. - Comment on Key Question 2 re patient characteristic: o Race/ethnicity has emerged as a prominent factor in rates of COVID-19. There have been reports that relate these to living environment (eg, denser housing) and working in	-Our Future Research section identifies considerations for future research studies -We agree and anticipate more data for future updates. -Most studies included all adults (age 18 and older); 2 had upper age limits for inclusion (1 enrolled only those under 85 years and 1 enrolled only those 65 or younger). We aren't able to call out results from older adults -Two studies reported on residence – 16% were nursing home residents in 1 study; 10% were care home residents in another. We aren't able to call out results from nursing home residents. Thank you for the suggestion. We added several patient characteristics to the Analytic Framework and KQ2.

Question Text	Comment	Response
	settings with more exposure (eg, essential workers, work w/o PPE). Is it possible to include these factors in the patient characteristics in Key Question 2? o Is it possible to include underlying frailty (which is related to but different from a count of co-morbidities and/or age) in the patient characteristics?	- No studies reported a measure of frailty; we agree with the suggestion and added frailty to the list of patient characteristics,
	- The Key Findings reported are mostly limitations of the studies available rather than findings from the studies, either individually or pooled. Were there no findings at all that could help inform post-acute care? Readers of the ESP review will be looking for what can be gleaned from the existing literature to inform practice. While including the limitations of the literature identified is important, this can be done in the Limitations section. It would be more helpful to clinical readership if the Key Findings could include more than findings about the state of the literature and could include any observations that can be made about post-acute organ damage.	- With the addition of 25 studies following peer review, we now offer prevalence ranges for several outcomes (see Table 2 and Key Findings). However, at this point, we also consider limitations of the available evidence to be a Key Finding. We hope that future reports of post-acute organ damage will allow for more insight into post-acute organ damage and care needs.
	- Recommend that Discussion section revisits the original Key questions and goes through each one, describing what information is available or not available to answer the question and providing answers to the Key Questions to whatever extent is possible.	Thank you for the suggestion. The Discussion section has been reorganized to provide responses to the Key Questions.
	o If it is possible to give a prevalence based on 1 or 2 papers, limited in generalizability because of the limitations of the papers, give the prevalence from those 1 or 2 papers with the limitation on the population, and explain why it is not possible to answer the question more broadly	As noted above, we now provide prevalence ranges for several outcomes.
	-	
	- There were 17 included studies. Table 2 shows 18 studies. Presumably 1 study is in 2 columns of organ system. A table footnote clarifying this would be helpful	Thank you for this observation. You are correct that 1 study is in 2 columns. We clarified this on the table.
	- Note that the section on Overview of included studies reports not only what were the outcomes tracked but also give the findings. This may be a part of ESP style in which case this is fine. Noting it in case this is not specifically ESP style	Thank you for noting this. The headings have been revised.
	Minor/editing comments:	Thank you for these comments. We added a legend to Table 2.

Question Text	Comment	Response
	- In Table 2, suggest identifying the major organs of interest by words as well as the graphics. Could be in the table legend. Most are clear but a few are not. - Should carefully distinguish patients who had COVID-19 (the disease) versus patients who were SARS CoV2 test positive and may or may not have had COVID-19. For example, on page 2 line 51, did all patients actually have the disease, or were some test positive and may have had the disease (or may not)?	Appendix C, Table 1. Study Characteristics describes the study population as reported by the study authors. In the Results section, we verified that we clearly distinguish studies where patients were hospitalized for another indication and tested positive for COVID-19.
	Very nice and encouraging that more permanent organ damage was not found.	Thank you although we expect additional data will be forthcoming that may change this observation.
	Thank you for the opportunity to review this rapid and extensive review of published literature. It is a solid report and extremely helpful to those of us conducting research and planning research on this topic. I have a couple suggestions that I think would improve the report, especially given that many of the studies rely on a wide range of data and varying data sources. My suggestions are below: P.7-regarding exclusion criteria, were any studies excluded due to retraction or quality of the study or study data? Given the problems experienced during the pandemic with the rapid publication process of some studies, such as the Surgisphere authored studies, attention to potential quality of studies is a sensitive issue. Although some elements based on the Briggs model for case series are noted and presented in detail in Table 2, you might want to address aspects related to observational study (retrospective and prospective) quality explicitly in your review methods. Notably the table 2 currently lacks any assessment of the data sources or the data quality. You may want to consider other criteria, such as that described by the STROBE- Altman D, Egger M, Pocock S, Vandenbrouke JP, von Elm E: Strengthening the reporting of observational epidemiological studies. STROBE Statement: Checklist of Essential Items; and most current Version 2007 - https://www.strobe-statement.org/index.php?id=available-checklists. This critical appraisal tool importantly includes some items to assess data and data sources.	Thank you P.7 We did not exclude studies for study quality. As of December 1, 2020, none of the studies has been retracted. We chose to continue to use the modified version of the Joanna Briggs checklist to identify overall study limitations. Although it would provide some guidance for critical appraisal, the STROBE checklist is intended to improve reporting by authors of observational studies.

Question Text	Comment	Response
	P.13-I suggest adding as part of the guidance that some detail about the data collection and or data sources should be included in the studies (and as noted above). NHLBI also provides has some good guidance on study data monitoring that explicate the process for data monitoring. Whether such procedures were applied in a study and reported in their manuscript could also be applied in a review. Guidance to researchers in reporting their studies should be encouraged to report about the extent of oversight and principles applied. Such as was there a Observational Study Data Monitoring Board (OSMB) or a protocol review committee in place and the members and frequency of review. This information about the study may inform how well the study was conducted and give more confidence in the study quality and results. I look forward to the final version of the rapid review.	P.13 As noted in the report, most of these early studies were convenience samples of patients admitted to a single hospital facility. We agree that data collection techniques and oversight are important and we will consider expanding on this in future versions of this living review.
	I think the report could more clearly identify different questions of interest that have different implications for study design: 1) If intent is purely descriptive/predictive, no control group may be necessary but the study population needs to be carefully described – need to distinguish severity of infection and whether selected for organ involvement or not. I think a weakness worth adding is that none included an inception cohort – i.e. all patients infected, or all patients hospitalized with COVID. 2) If the purpose is to tease out COIVD specific effects, it is important to have a comparable control group – e.g. influenza for pulmonary complications; other age/matched hospitalized patients for other organ effects, etc. 3) The effects of changing treatment need to be called out – likely different now that patients being treated earlier with steroids.	Thank you for the suggestions. We reviewed and modified our Future Research section.
	Thank you for the opportunity to review this VA Evidence Synthesis Program rapid review on post-acute COVID-19 major organ damage – the topic is highly relevant to the ongoing care of our patients. The manuscript documents registration with PROSPERO and includes a detailed discussion of methodology (PRISMA-based).	Thank you

Question Text	Comment	Response
	1. Suggest inclusion of the PRISMA checklist as is customary in systematic reviews (for example, as one of your appendices) – the subcomponent steps appear to be present; linking the checklist to the document will ensure completeness, facilitate review(s), and enhance end-user confidence in your results.	1. Thank you for the suggestion.
	2. Page 10, lines 53-56. Can you clarify what the disposition was of the other patients in this study (n=114)? It appears that 49 were discharged home (35%) but only 13 (9%) were transferred to a “rehabilitation” center. Readers may wonder what happened with the majority of patients in this study (the other 52 patients).	2. We clarified that the numbers are for patients who were discharged. In-hospital deaths and patients remaining hospitalized were not represented in these numbers.
	3. Typos page 11, line 11-15: you’ll need to choose between saying a % “of patients” or just a % without an object (object implied). For example, line 11 currently reads “The authors noted that 4% (4/108) patients initially discharged home…” Suggest adding “of” before “patients” in this sentence. Same issue in the following sentence.	3. We reviewed the document and corrected as needed. This particular sentence is no longer included in the final document.
	4. Page 11, line 17. Strongly suggest you clarify that these studies are not actually reporting recurrence of COVID-19, which are you know has indeed been reported now but which is not what these studies are reporting. Rather, it’s rates of positive testing – almost certainly rates of continued positivity versus reinfection.	4. Thank you for the suggestion. We clarified the recurrence data.
	5. Key Finding bullet point 4, “…little or no information on post-hospital care…” The last paragraph on page 10 describes four studies (one very small one) that report rates of transfer to rehabilitation settings. Two thoughts: first, these rates of needing formal post-acute care in a facility seem to be lower than what we are seeing. Second, suggest you indicate in the body of the text that details on what the post-acute care needs were (in these studies) was not reported. The key finding here reads like it’s introducing information (the lack of detail on post-acute care needs) rather than summarizing what you’ve presented in the text.	5. Thank you. This bullet has been revised to provide detals on what types of post-acute care we were looking for (outlined in our Analytic Framework).
	6. The last two key findings seem like limitations. Suggest moving them into the limitations section.	6. We modified the Key Findings and Limitations sections.
	7. Page 12, line 46-7: as you are making recommendations	

Question Text	Comment	Response
	around future research, suggest you not phrase this as a question. Rather, state what populations future research should / should not include and the need to define them in whatever ways you suggest.	7. Thank you for the suggestion. We removed this line.
	Page 6: Under the 'Potential Healthcare or Service Use Needs' box in the flow map, under 'Treatments', should there be reference to OT and PT post discharge needs?	Thank you for the suggestion – we added OT and PT to the Framework.

APPENDIX C. EVIDENCE TABLES

Table 1. Study Characteristics

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Al Kasab, 2020[21] USA, South America, Europe (28 centers) Prospective Funding: None	Inclusion: Consecutive patients undergoing mechanical thrombectomy (MT) for large vessel occlusion; symptomatic patients were tested with RT-PCR methods Exclusion: None reported	N=13 COVID positive (NOTE: 458 patients underwent MT; 242 were tested for COVID) Age (years, median): 58 Gender (% male): 62 Race: 46% white Comorbidities: NR CVD: CKD: COPD: DM: HTN: Obesity: Smoking:	COVID-19 severity: NR ICU admission: NR Mechanical ventilation: 39% Length of hospital stay (median): 8 days Time post-hospital: 0 days (discharge)	Modified Rankin Scale
Alharthy, 2020[22] Saudi Arabia Prospective Funding: Hospital	Inclusion: Age >18 years; confirmed serious COVID-19 pneumonia (RT-PCR for SARS-CoV-2); ICU admission Inclusion: Did not undergo POCUS; 2 consecutive negative RT-PCR results at least 24 hours apart	N=89 Age (years, median): 43 Gender (% male): 84 Race: NR Comorbidities: NR CVD: CKD: COPD: DM: HTN: Obesity: Smoking:	COVID-19 severity: 100% severe ICU admission: 100% Mechanical ventilation: 84% on ICU admission; 100% within 48 hours Length of hospital stay: NR Time post-hospital: 0 days (discharge)	POCUS (thorax) and vascular ultrasound of lower limbs; chest CT if high suspicion of PE
Atalla, 2020[60] USA	Inclusion: Discharged from hospital; confirmed COVID-19 (RT-PCR for SARS-CoV-2);	N=339 (n=19 readmitted, n=320 not readmitted) Age (years, median): 61	COVID-19 severity: NR ICU admission: 33%	Discharge disposition (for readmitted patients)

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Retrospective Funding: Not reported	criteria for hospital admission were individualized – in general patients with significant comorbidities and moderate to severe COVID-19 (requiring O2 and having abnormal imaging findings) were admitted Exclusion: None reported	Gender (% male): 56 Race: 37% Hispanic, 1% Asian, 16% African American, 43% Caucasian, 3% Other Comorbidities: CVD: NR CKD: 11%; P=NS between groups COPD: 15% Readmitted: 58%, Not Readmitted: 13%; P<.001 DM: 33% Readmitted: 58%, Not Readmitted: 32%; P=.021 HTN: 45% Readmitted: 68%, Not Readmitted: 44%; P=.038 Obesity: 40%; P=NS between groups Smoking: NR	Readmitted: 11%, Not Readmitted: 34%; P=.032 Mechanical ventilation: 19% Readmitted: 0%, Not Readmitted: 20%; P=.030 Length of hospital stay (median): 7 days (IQR 4-15) Time post-hospital: followed for 30 days	Readmission to 30 days Reason for readmission PCR, imaging, and support needed on readmission NOTE: Patients discharged were instructed to see medical care for relapse of fever, shortness of breath, neurological or thrombotic events, or any change in clinical status; patients received a post-discharge follow-up call to monitor recovery process
Benussi, 2020[23] Italy Retrospective cohort Funding: None	Inclusion: Adult (≥18 years) admitted primarily for neurological disease; had outcome of discharge (home or rehabilitation facility) or death; SARS-CoV-2 detected by RT-PCR methods; confirmed COVID-19 Exclusion: None reported NOTE: reporting data only for patients with *cerebrovascular disease* on admission	N=111 (43 with COVID-19; 68 non-COVID-19) Age (years, mean): 76 Gender (% male): 56 Race: NR Comorbidities: CVD: 14% CKD: 5% COPD: NR DM: 22% HTN: 69% Obesity: NR Smoking: 6%	COVID-19 severity: NR ICU admission: NR Mechanical ventilation: NR Length of hospital stay: 5 days Time post-hospital: 0 days (discharge)	NIH Stroke Scale at discharge for COVID-19 and non-COVID-19 cases “Good” outcome
Casas-Rojo, 2020[38] Spain	Inclusion: Spanish Society of Internal Medicine registry; age ≥18 years; first hospital	N=15,111 Age (years, median): 69 Gender (% male): 57	COVID-19 severity: NR ICU admission: 8%	Readmission within 30 days

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Retrospective cohort Funding: Foundation/Society	admission; hospital discharge or in-hospital death (consecutive patients with confirmed SARS-CoV-2 (positive RT-PCR or positive result on serological testing and compatible clinical presentation) were eligible Exclusion: Subsequent admissions of the same patient; denial or withdrawal of consent	Race: 90% Caucasian, 10% Other Comorbidities: CVD: 20% CKD (moderate-severe): 6% COPD: 7% DM: 19% HTN: 51% Obesity (BMI ≥30 kg/m^2): 21% Smoking: 69% Never, 25% Moderate, 5% Current NOTE: 4% were healthcare workers	Mechanical ventilation: 7% Invasive, 5% Non-invasive Length of hospital stay: 10 days (range 1-62) (discharged patients) Time post-hospital: median follow-up 40 days (range 0-102 days)	
Chan, 2020[24] USA Retrospective Funding: Several authors report funding; unclear if related to manuscript	Inclusion: Age ≥18, laboratory-confirmed SARS-CoV-2 and COVID-19 admitted to 1 of 5 Mount Sinai Health System hospitals 2/27/20-5/30/20 Exclusion: Known end stage kidney disease prior to admission; hospitalized <48 hours, missing laboratory and vital signs during hospitalization	N=3,993 (demographics for all patients admitted; 3,869 [97%] were discharged) *(NOTE: 46% (1,835/3,993) experienced AKI while hospitalized*) Age (years, median): 64 Gender (% male): 57 Race: White 24%, Black 36%, Hispanic 26%, Asian 4%, Other or unknown 19% Comorbidities: CVD: NR CKD: 11% COPD: NR DM: 26% HTN: 38% Obesity: NR Smoking: NR	COVID-19 severity: NR ICU admission: 24% (976/3993) Mechanical ventilation: 23% (929/3993) Length of hospital stay (discharged patients, median): AKI group 10 days, no AKI group 7 days (P<.001) Time post-hospital: 0 days (discharge)	AKI; compared last hospital creatinine with baseline; grouped as recovered or with AKI Stage 1, 2, or 3 Recovered: difference in creatinine is ≤0.3 and change in % ≤25% Stage 1: difference >0.3 and change >25% and ≤100% Stage 2: change in % >100% and ≤200% Stage 3: change in % >200%
Collins, 2020[25] USA Retrospective	Inclusion: Persons with HIV admitted with COVID-19 (detection of SARS-CoV-2 via RT-PCR)	N=20 Age (years, median): 57 Gender (% male): 65	COVID-19 severity: NR ICU admission: 30%	Discharge disposition

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Funding: University	Exclusion: None reported NOTE: study sites included Atlanta Veterans Affairs Medical Center	Race: 85% Non-Hispanic Black, 5% Non-Hispanic White, 5% Non-Hispanic/Multiracial, 5% Hispanic/Latino Comorbidities: CVD: 30% CKD: 25% Chronic lung disease: 30% DM: 45% HTN: 70% Obesity: 30 Smoking: 50% Current, 10% Former, 40% Never	Mechanical ventilation: 15% Length of hospital stay (days, median): 5 Time post-hospital: 0 days (discharge)	
Curci, 2020[26] Italy Cross-sectional Funding: None	Inclusion: Consecutive referrals to rehabilitation unit; adults (>18); diagnosis of viral interstitial lung disease (CT); positive for SARS-CoV-2 (RT-PCR); previously hospitalized in ICU; clinical stability (able to perform bedside mobilization without reduction in oxygen saturation below 90%); complete weaning from sedative and antipsychotic drugs Exclusion: Respiratory distress signs; cognitive impairment; need of respiratory support (FiO_2 >60%); need of CPAP devices; signs of cardiovascular instability	N=32* Age (years, mean): 73 Gender (% male): 69 Race: NR Comorbidities: CVD: NR CKD: NR COPD: 6% DM: 19% HTN: 63% Obesity: NR Smoking: 28% *Subgroups 1) FiO_2 ≥21% and <40% (n=13); without oxygen support devices or wearing nasal cannula 2) FiO_2 ≥40% and <60% (n=19); wearing non-rebreather mask, Venturi mask, or oxygen mask	COVID-19 severity: NR ICU admission: 100% Mechanical ventilation: NR Length of hospital stay: 16.4 days (patients went from ICU to rehabilitation unit) Time post-hospital: at admission to rehabilitation unit	Degree of alteration in PaO_2/FiO_2 ratio Respiratory supports needed Dyspnea scale (levels)

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Dennis, 2020[39] United Kingdom Prospective PREPRINT Funding: Government	Inclusion: Positive for SARS-CoV-2 by RT-PCR (n=62), positive antibody test (n=63), or determined to have COVID-19 by 2 independent clinicians based on symptoms (n=73) Exclusion: Symptoms of active respiratory viral infection; discharged from hospital in last 7 days; contraindications to MRI (metallic implanted devices, claustrophobia)	N=37 (patients hospitalized only) Age (years, mean): 50 Gender (% male): 38 Race/ethnicity: 76% White, 8% South Asian, 5% Black Comorbidities: Previous heart disease: 3% CKD: NR COPD: NR DM: 0% HTN: 5% Obesity: NR Smoking: 65% never, 35% former, 0% current NOTE: 35% were health care workers	COVID-19 severity: NR ICU admission: NR Mechanical ventilation: NR Length of hospital stay: NR Time post-hospital: NR (median of 105 days after COVID-19 positive)	Organ function by patient-reported questionnaires, fasting blood investigations, and multi-organ MRI
Egol, 2020[40] USA Prospective Funding: None	Inclusion: Hip fracture; positive RT-PCR test before, during, or after (at rehabilitation) hospitalization Exclusion: None reported NOTE: Included comparison data from COVID-19 Suspected and COVID-19 Negative patients	N=17 (COVID-19 positive) Age (years, mean): 82 Gender (% male): 71 Race/ethnicity: 82% White, 0% African American, 12% Hispanic, 6% Asian Comorbidities: CVD: 47% CKD: 24% (renal failure) COPD: 18% DM: 41% HTN: 65% Obesity: NR Smoking: 53% Never, 35% Former, 12% Current	COVID-19 severity: NR ICU admission: 29% Mechanical ventilation: 12% Length of hospital stay: 9.8 days Time post-hospital: to 30 days	Readmission within 30 days Discharge post-acute rehabilitation
El Moheb, 2020[41] USA	Inclusion: All patients with confirmed SARS-CoV-2 (RT-PCR) who were intubated and admitted to ICU	N=92 (propensity matched subgroup with COVID-19 ARDS) Age (years, median): 62 Gender (% male): 59	COVID-19 severity: NR ICU admission: 100% (inclusion criteria)	Emergency department readmission

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Retrospective Funding: Not reported	Exclusion: None reported NOTE: analysis was limited to patients whose gastrointestinal complications while hospitalized were previously reported; propensity score matching with to identify comparably ill patients with non-COVID-19 ARDS	Race/ethnicity: NR Comorbidities: CAD: 13% CKD: 20% Chronic lung disease: 29% DM: 37% HTN: 55% Obesity: NR Smoking: 39%	Mechanical ventilation: NR Length of hospital stay: median 24 days Time post-hospital: NR	
Fisher, 2020[27] USA Retrospective Funding: None	Inclusion: Age >18 years with COVID-19 test performed upon hospitalization; confirmed case of COVID-19 was a positive RT-PCR result Exclusion: Age <18 years; end stage kidney disease; no creatinine values; unknown sex assignment NOTE: included comparison group of patients hospitalized during same time period in 2019	N=3,345 (positive for COVID-19; total of 4,610 were eligible and tested Age (years, mean): 64 Gender (% male): 53 Race: 8% Non-Hispanic White; 36% Non-Hispanic Black, 37% Hispanic; 19% Other Comorbidities: CVD: NR CKD: 12% COPD: NR DM: 27% HTN: NR Obesity: 43% Smoking: NR NOTE: 16% were nursing home residents	COVID-19 severity: NR ICU admission: 13% Mechanical ventilation: 18% Length of hospital stay: 5 days Time post-hospital: 0 days (discharge)	Discharge disposition
Frija-Masson, 2020[42] France Retrospective	Inclusion: Age <85; confirmed SARS-CoV-2 infection (RT-PCR); discharged from hospital; evaluated with pulmonary function tests 30	N=50 Age (years, median): 54 Gender (% male): 56 Race: NR Comorbidities:	COVID-19 severity: 50% severe (based on CT) ICU admission: 14% (7/50) Mechanical ventilation: 2% (1/50)	Pulmonary function test interpretation

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Funding: Not reported	days after symptom onset as part of routine care Exclusion: Decline to participate; recurrence; patients with ARDS NOTE: 18% (9/50) treated as outpatients	CVD: NR CKD: NR COPD: NR DM: 16% HTN: 48% Obesity: NR Smoking: 10% active; 18% former	Length of hospital stay: NR Time post-hospital: NR (30 days after symptom onset)	
Fuglebjerg, 2020[28] Denmark Case series Funding: None	Inclusion: Hospitalized with COVID-19 confirmed by PCR testing Exclusion: Chronic lung diseases or New York Heart Association (NYHA) class II or above	N=26 Age (years, median): 63 (range 29-85) Gender (% male): 62 Race: NR Comorbidities: NR (patients had a median of 1 (non-specified) per patient) CVD: CKD: COPD: DM: HTN: Obesity: Smoking:	COVID-19 severity: NR ICU admission: 31% Mechanical ventilation: 15% Length of hospital stay: NR Time post-hospital: 0 days (discharge)	Hypoxia and dyspnea elicited by 6-minute walking test Exercise-induced hypoxia: $Sp0_2$ <90% (test terminated) Dyspnea: Borg Scale (0-10)
Garrigues, 2020[43] France Prospective, survey Funding: None	Inclusion: Hospitalized in COVID-19 ward; positive SARS-CoV-2 (RT-PCR) and/or typical abnormalities on chest CT Exclusion: Directly admitted to ICU without being hospitalized in COVID-19 unit; deceased, unreachable by telephone, demented, bedridden, non-French speaking	N=120 Age (years, mean): 63 Gender (% male): 63 Race: NR Comorbidities: CVD: NR CKD: NR COPD: NR DM: 22% HTN: 47% Obesity: NR	COVID-19 severity: NR ICU admission: 20% Mechanical ventilation: 12% Length of hospital stay (days, mean): 13 Time post-hospital (mean): 111 days	Telephone questionnaire for post-discharge clinical symptoms, modified Medical Research Council (mMRC) dyspnea scale score, professional and physical activities, and attention, memory and/or sleep disorders

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
		Smoking: NR		
Goicoechea, 2020[29] Spain Retrospective Funding: Not reported	Inclusion: All patients on maintenance hemodialysis admitted with positive RT-PCR testing for SARS-CoV-2 infection Exclusion: None reported	N=36 (7 were discharged) Age (years, mean): 71 Gender (% male): 64 Race: NR Comorbidities: CVD: 22% CKD: 100% COPD: 19% DM: 64% HTN: 97% Obesity: NR Smoking: NR	COVID-19 severity: NR ICU admission: 3% (1/36) (NOTE: severe comorbidities in 11 other patients requiring mechanical ventilation limited invasive measures) Mechanical ventilation: “assisted” 33% (12/36) Length of hospital stay (discharged patients, median): 11.4 days Time post-hospital: 0 days (discharge)	“Lung abnormalities”
Grewal, 2020[30] USA Retrospective Funding: Not reported	Inclusion: Diagnosis of acute ischemic stroke (AIS) (confirmed with MRI or CT); positive for COVID-19 (RT-PCR); divided patients into “COVID” group (initially with COVID-19 symptoms who developed AIS) and “neuro” group (admitted for AIS and tested positive for COVID-19) (NOTE: included control groups of non-COVID-19 AIS patients hospitalized during study time frame and in 2019) Exclusion: None reported	N=13 (6 in “COVID” group, 7 in “neuro” group) Age (years, mean): 62 Gender (% male): 46 Race: 46% Latino, 31% African-American Comorbidities: CAD: 15% CKD: NR COPD: NR DM: 69% HTN: 69% Obesity: 15% Smoking: NR	COVID-19 severity: 8 (62%) severe or critical; 5 (38%) mild or regular ICU admission: NR Mechanical ventilation: NR Length of hospital stay: NR Time post-hospital: 0 days (discharge)	Discharge disposition Discharge mRS >2

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Hong, 2020[44] China Retrospective Funding: Government	Inclusion: All SARS-CoV-2 positive (RT-PCR) patients admitted to 2 hospitals (NOTE: subgroup followed after discharge) Exclusion: None reported	N=29 (subgroup followed) Age (years, mean): 44 Gender (% male): 52 Race: NR Comorbidities: NR CVD: CKD: COPD: DM: HTN: Obesity: Smoking:	COVID-19 severity: 34% (10/29) mild, 41% (12/29) moderate, 17% (5/29) severe, 7% (2/29) critical (defined as needing mechanical ventilation or ICU admission) ICU admission: see above Mechanical ventilation: see above Length of hospital stay): NR Time post-hospital (mean(SD)): 21 (7) days	NOTE: unclear if followed until or after discharge Positive cases after recovery
Huang L, 2020[45] China Retrospective Funding: Foundation, Government	Inclusion: Consecutive patients referred for CMR due to cardiac symptoms after discharge; previously confirmed with SARS-CoV-2 (RT-PCR); considered recovered by hospital discharge criteria Exclusion: History of CAD or myocarditis; contraindication to gadolinium contrast; CMR image quality not sufficient for analysis	N=26 Age (years, median): 38 Gender (% male): 38 Race: NR Comorbidities: CAD: 0% CKD: 0% COPD: 0% DM: 0% HTN: 8% Obesity: NR Smoking: NR NOTE: also included data from healthy controls (similar age and gender distribution, no CVD or systemic inflammation) who underwent CMR at same hospital	COVID-19 severity: 0 critical, 4 severe, 22 moderate ICU admission: NR Mechanical ventilation: 0% (12% received noninvasive ventilation or high-flow nasal cannula oxygen Length of hospital stay: NR Time post-hospital: NR NOTE: Median time from cardiac symptom onset to CMR was 47 days	Cardiac magnetic resonance imaging findings
Huang Y, 2020[46] China	Inclusion: Age over 18 years; released from hospital over 1	N=57 Age (years, mean): Severe: 53; Non-severe: 44; P=.03	COVID-19 severity: 17 severe, 40 non-severe	Pulmonary fibrosis

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Retrospective Funding: Not reported	month; confirmed SARS-CoV-2 infection (RT-PCR) Exclusion: Previous history of pulmonary resection, neurological disease, or mental illness; could not be contacted or declined participation	Gender (% male): Severe 71%; Non-severe: 35%; P=.01 Race: NR Comorbidities: CVD: 5% CKD: NR COPD: 0% DM: 7% HTN: 19% Obesity: NR Smoking: 16%	ICU admission: NR Mechanical ventilation: NR Length of hospital stay: 21 days Time post-hospital: 30 days	Impairment of diffusion capacity Impairment of lung volumes Impairment of respiratory muscle strength
Katz, 2020[31] USA Retrospective Funding: None	Inclusion: Confirmed SARS-CoV-2 infection (RT-PCR); concurrent stroke diagnosis (stroke symptom onset during COVID-19 illness or onset of COVID-19 symptoms or SARS-CoV-2 positivity within 14 days of stroke symptom onset) confirmed by imaging Exclusion: None reported NOTE: included control group of all stroke patients admitted 1 year earlier between same dates to same hospitals	N=86 Age (years, mean): 67 Gender (% male): 56 Race: 30% White, 31% Black, 12% Asian, 27% Multiracial/other Comorbidities: CVD: NR CKD: NR COPD: NR DM: NR HTN: NR Obesity (BMI ≥30 kg/m^2): 31% Smoking: NR	COVID-19 severity: among n=45 testing positive for COVID-19 after stroke symptoms 51% (23/45) had mild COVID-19 symptoms and 29% (13/45) were asymptomatic ICU admission: 51% (critical care admission) Mechanical ventilation: 44% Length of hospital stay: NR Time post-hospital: 0 days (discharge) NOTE: 48% (41/86) had stroke onset during hospitalization for COVID-19	Discharge disposition
Knights, 2020[61] United Kingdom Retrospective	Inclusion: Admitted to hospital with positive COVID-19 test Exclusion: None reported	N=108 Age (years, mean): 69 Gender (% male): 58 Race: White British: 76%	COVID-19 severity: NR ICU admission: NR Mechanical ventilation: 8%	Discharge disposition Readmission Care needs

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Funding: Not reported		Comorbidities: CVD: NR CKD: 6% COPD: 15% DM: 23% HTN: 45% Obesity: 31% Smoking: 44% Ex or current, 56% never NOTE: 10% were care home residents; 21% had a “package of care”	Length of hospital stay (days, median): 8 [IQR 4-13] Time post-hospital: median follow-up from time of admission to either death or study end date: 26 days [IQR 18-31]	
Liotta, 2020[32] USA Retrospective Funding: Not reported	Inclusion: Admitted with COVID-19; diagnosis confirmed by SARS-CoV-2 RT-PCR Exclusion: None reported	N=509 Age (years, mean): 59 Gender (% male): 55 Race: 53% White, 30% Black or African American, 4% Asian, 13% Other/Unknown/Declined Comorbidities: CVD: NR CKD: 11% COPD: Nr DM: 30% HTN: 54% Obesity (BMI >30 kg/m^2): 52 Smoking: 28% Current	COVID-19 severity: 26% severe ICU admission: NR Mechanical ventilation: 26% Length of hospital stay (days, median): 7 Time post-hospital: 0 days (discharge)	Modified Rankin Scale score
Lovinsky-Desir, 2020[47] USA Retrospective	Inclusion: Sequential patients 65 years or younger; positive for severe SARS-CoV-2 (RT-PCR); hospitalized or died in the emergency department Exclusion: None reported	N=1243 (age 21-29 [n=300] and 40-65 [n=943] groups only) Age (years, median): Age 21-39: 31-32 years Age 40-65: 56-58 years Gender (% male): 59 Race: 22% Black, 19% White, 1% Asian, 35% Other (NOTE: race	COVID-19 severity: 100% severe defined as hospitalization with confirmed positive SARS-CoV-2 PCR result or death in emergency department ICU admission: NR	Readmission

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Funding: Government, Foundation		identification declined for some patients) Comorbidities: CVD: NR CKD: NR COPD: 0% (excluded from analysis) DM: NR HTN: NR Obesity: 42% Smoking: 59% Never, 4% Current, 11% Former (NOTE: smoking status missing for some patients)	Mechanical ventilation: 21% (intubation) Length of hospital stay: 4-6 days (medians) Time post-hospital: NR	
Mo, 2020[33] China Cross-sectional Funding: Government	Inclusion: Hospital admitted; laboratory confirmed noncritical COVID-19 Exclusion: Critical cases	N=110 Age (years, mean): 49 Gender (% male): 50% Race: NR Comorbidities: CVD: 3% Kidney disease: 2% Lung disease: 3% DM: 8% HTN: 24% Obesity: NR Smoking: 12%	COVID-19 severity: 22% mild, 61% pneumonia, 17% severe pneumonia ICU admission: 0% Mechanical ventilation: 0% Length of hospital stay: NR Time post-hospital: 0 days (discharge)	Spirometry Diffusion capacity
Ng, 2020[34] USA Retrospective Pre-proof Funding: Not reported	Inclusion: All adult (age ≥18 years) patients who tested positive for COVID-19 (RT-PCR); hospitalized in 1 of 13 hospitals in a large health system Exclusion: Transferred to hospitals outside the health	N=9,657 (demographic data for 40% [3,854/9,657] who developed AKI while hospitalized; 638 [17%] required KRT) Age (years, medians): KRT: 64 Non-KRT: 71 (P<.001) Gender (% male): KRT: 79	COVID-19 severity: NR ICU admission: KRT: 92%, Non-KRT: 45% (P<.001) Mechanical ventilation: KRT: 92%, Non-KRT 41% (P<.001)	Need for dialysis at discharge among patients who developed AKI, required dialysis, and survived Kidney recovery at discharge among patients who developed AKI (requiring or

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
	system; admitted to inpatient obstetric service; end stage kidney disease; prior kidney transplant; <2 serum creatinine levels during admission	Non-KRT: 58 (P<.001) Race/Ethnicity: KRT: 25% Non-Hispanic White, 22% Non-Hispanic Black, 22% Hispanic Non-KRT: 38% Non-Hispanic White, 21% Non-Hispanic Black, 19% Hispanic (P<.001) Comorbidities (all P<.001): CAD: KRT: 13%, Non-KRT: 18% CKD: KRT: 7%, Non-KRT: 9% COPD: KRT: 6%, Non-KRT: 8% DM: KRT: 48%, Non-KRT: 43% HTN: KRT: 64%, Non-KRT: 69% Obesity: BMI 30 or higher KRT: 45%, Non-KRT: 32% Smoking: KRT: 64% never, 22% current, 14% unknown Non-KRT: 67% never, 23% current, 10% unknown (P<.001)	Length of hospital stay (median): KRT: 29 days; Non-KRT: 12 days Time post-hospital: 0 days (discharge)	not requiring dialysis) and survived
Ntaios, 2020[35] Multi-national (Global COVID-19 Stroke Registry) Retrospective Funding: None	Inclusion: Hospitalized with laboratory-confirmed COVID-19 (96% by PCR, 4% by serology) and acute ischemic stroke (NOTE: median delay between initiation of COVID-19 symptoms and stroke onset=7 days [IQR 2-15]) Exclusion: Infected after onset of stroke (NOTE: also included propensity matched group of	N=174 Age (years, median): 71 Gender (% male): 62 Race: NR Comorbidities: CAD: 17% CVD: NR Kidney disease: NR Lung disease: NR DM: 31% HTN: 68% Obesity: 37% Smoking: 28%	COVID-19 severity: NR ICU admission: 23% (40/174) Mechanical ventilation: 16% (17/174) Length of hospital stay: NR Time post-hospital: 0 days (discharge)	Modified Rankin Scale score

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
	non-COVID-19 patients from other registries)			
Patell, 2020[48] USA Retrospective Funding: Not reported	Inclusion: Age ≥18 years; positive for SARS-CoV-2 (RT-PCR) Exclusion: Hospitalized at time of analysis; discharged without any form of post-discharge contact in hospital medical records; discharged on therapeutic anticoagulation (separate reporting for patients discharged on prophylactic-dose anticoagulation)	N=163 Age (years, median): 58 Gender (% male): 48 Race: 37% White Comorbidities: Heart disease: 12% CKD: 10% Chronic respiratory disease: 22% DM: 31% HTN: 53% Obesity: NR Smoking: NR	COVID-19 severity: NR ICU admission: 26% Mechanical ventilation: NR Length of hospital stay (days, median): 6 Time post-hospital: discharge to 30 days	Cumulative incidence of thrombosis or hemorrhage at 30 days post-discharge Readmission
Paterson, 2020[36] United Kingdom Retrospective case series Funding: Several authors receive funding; not specified if related to this project	Inclusion: Patients referred to COVID-19 neurology/encephalitis and neurovascular multi-disciplinary team meetings; “definite” cases determined with RT-PCR Exclusion: None reported	N=43 (demographic data for 16 with definite COVID-19 diagnosis and discharged) Age (years, mean): 57 Gender (% male): 56 Race: 63% White, 23% Black, 13% Asian Comorbidities: CVD: NR CKD: NR COPD: NR DM: 6^ HTN: 38% Obesity: NR Smoking: NR	COVID-19 severity: 13% critical, 25% severe, 63% mild ICU admission: 25% Mechanical ventilation: NR Length of hospital stay: 16.6 days (reported for 12 patients) Time post-hospital: 0 days (discharge)	Discharge disposition
Puntmann, 2020[49] Germany	Inclusion: Minimum of 2 weeks post-diagnosis of SARS-CoV-2 by RT-PCR; resolution of respiratory symptoms; negative	N=100 Age (years, mean): 49 Gender (% male): 53 Race: NR	COVID-19 severity: 18% asymptomatic, 49% mild/moderate (both recovered at home), 33% severe (required hospitalization)	Cardiac magnetic resonance imaging findings Blood test results

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Prospective Funding: Government, Industry, Institution	results on swab test at end of isolation period Exclusion: Recently recovered from COVID-19 and referred for clinical CMR imaging; unwilling to participate; absolute contraindications for contrast-enhanced magnetic resonance study	Comorbidities: CVD: 13% CKD: NR COPD: 21% DM: 18% HTN: 22% Obesity: NR Smoking: 22%	ICU admission: NR Mechanical ventilation: 6% (2/33) (52% (17/33) required non-invasive ventilation) Length of hospital stay: NR Time post-hospital: NR (NOTE: median time from diagnosis to CMR was 71 [IQR 64-92] days)	
Richardson, 2020[50] USA Case Series Funding: Government	Inclusion: Consecutive patients at 12 hospitals in an academic health system requiring hospital admission with confirmed SARS-CoV-2 infection (RT-PCR) Exclusion: None reported	N=5,700 (2,081 were discharged) Age (years, median): 63 Gender (% male): 60 Race: African American 23%, Asian 9%, White 40%, Multiracial 29% Comorbidities: CAD: 11% CKD: 5% COPD: 5% DM: 34% HTN: 57% Obesity: 42% Smoking:16%	COVID-19 severity: NR ICU admission (discharged): 4% (82/2081) Mechanical ventilation (discharged): 2% (38/2081 Length of hospital stay (medians, discharged patients): <18 years (n=32): 2.0 days 18-65 years (n=1,373): 3.8 days >65 years (n=676): 4.5 days Time post-hospital (median): 4.4 days	Readmission Discharge disposition (home or facility [eg, nursing home or rehabilitation)
Roberts, 2020[51] United Kingdom Prospective Funding: Not reported	Inclusion: Patients discharged following admission for COVID-19; 6-week follow-up for hospital-associated VTE (HA-VTE) events Exclusion: None reported	N=1877 Age (years, mean): NR Gender (% male): NR Race: NR Comorbidities: NR CVD: CKD:	COVID-19 severity: NR ICU admission: NR (11% [208/1877] admitted to critical care) Mechanical ventilation: NR	VTE episodes (medical database) within 6 weeks of discharge

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
	NOTES: 1) patients received thromboprophylaxis while hospitalized 2) comparison cohort of post-discharge HA-VTE following medical admission in 2019	COPD: DM: HTN: Obesity: Smoking:	Length of hospital stay: NR Time post-hospital: discharge to 6 weeks	
Sachdeva, 2020[52] USA Retrospective Funding: None	Inclusion: Age ≥18 years; end stage kidney disease on chronic peritoneal dialysis; hospitalized with COVID-19 (positive by PCR testing)	N=11 Age (years, median): 54 (<50: 36%; 50-59: 27%; 60-69: 27%; 70-79: 9%) Gender (% male): 27 Race: 9% Hispanic, 45% Non-Hispanic Black; 9% Non-Hispanic White; 36% Other or Unknown Comorbidities: CAD: 9% CKD: 100% COPD: 0% DM: 45% HTN: 91% Obesity (BMI ≥30 kg/m^2): 36% Smoking: 82% Never, 18% Former	COVID-19 severity: NR ICU admission: 27% Mechanical ventilation: 27% Length of hospital stay (days, mean): 9 (range 2-23) Time post-hospital: NR	Hospital readmission
Somani, 2000[53] USA Retrospective Funding: Government	Inclusion: Age ≥18 years; laboratory confirmed SARS-CoV-2; admitted and subsequently discharged alive from 5 health system hospitals Excluded: Discharge before April 12, 2020 (all patients had ≥14 day observation for possible readmission); returned <12 hours after discharge; died during index admission	N=2,864 (n=103 returned to hospital; 2,761 did not) Age (years, median): 66 Gender (% male): 58 Race: 4% Asian, 28% Black, 27% Hispanic, 24% White; 17% Unknown/Other NOTE: no differences between groups for Age, Gender, or Race Comorbidities: CAD: 8.1% CKD: 4.7%	COVID-19 severity: NR ICU admission: Returned: 6%; No Return: 19%; P=.001 Mechanical ventilation: Returned: 1%; No Return: 11%; P=.003 Length of hospital stay (days, median): Returned: 4.7; No Return: 7; P=.006	Return to hospital following discharge Reasons for return Readmission

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
		COPD: Returned: 7%; No Return: 3%; P=.035 DM: 15% HTN: Returned: 35%; No Return: 22%; P=.003 Obesity: NR Smoking: NR	Time post-hospital: 14 days	
Suleyman, 2020[62] USA Retrospective case series Funding: Not reported	Inclusion: Consecutive adult patients evaluated at 5 hospitals and 9 emergency departments in a health system; confirmed SARS-CoV-2 infection (RT-PCR) Exclusion: Lack of demographic and baseline data	N=355 (hospitalized) (108 discharged home after initial evaluation not reported here) Age (years, mean): 61 Gender (% male): 47 Race: 73% African American Comorbidities: CAD: 16% CKD: 45% COPD: 12% DM: 43% HTN: 73% Obesity: 59% Smoking: 39%	COVID-19 severity: NR ICU admission: 40% Mechanical ventilation: General practice unit: 0% (0/234) ICU: 81% (114/141) P<.001 Length of hospital stay (days, median [IQR]): General practice unit: 5 [3-7] ICU: 15 [9-23] P<.001 Time post-hospital: discharge to 30 days	Discharge disposition 30-day hospital readmission 30-day mortality
Tian, 2020[54] China Retrospective Funding: Not reported	Inclusion: COVID-19 patients discharged from hospital; discharge criteria included 2 consecutive RT-PCR tests (sampling interval at least 24 hours) Exclusion: NOTE: patients were placed in designated locations for centralized isolation and health	N=20 (“re-positive” cases from n=147 patients followed) Age (years, mean): 37 Gender (% male): 55 Race: NR Comorbidities: CVD: 5% (coronary heart disease) CKD: 0% COPD: 0% DM: 10% HTN: 25%	COVID-19 severity: 10% critical, 15% severe, 60% ordinary (moderate), 15% mild ICU admission: NR Mechanical ventilation: NR Length of hospital stay: 18.7 days	“Re-positive’ RT-PCR post-discharge

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
	monitoring for at least 28 days after discharge	Obesity: NR Smoking: NR	Time post-hospital: average of 17.3 days to 're-positive' results (range 7-47)	
Vizcaychipi, 2020[37] United Kingdom Prospective Funding: None	Inclusion: Admitted to Emergency Department; completed hospital encounter (discharged alive or died) Exclusion: Remained in admitting hospital; transferred to another hospital NOTE: study was designed to evaluate the effect of an electronic medical record alert system on early mortality related to COVID-19	N=1,039 admitted; data for n=939 who completed hospital encounter Age (years, median): 67 Gender (% male): 60 Race: 62% White Comorbidities: CVD: NR CKD: NR COPD: 10% DM: 38% HTN: 53% Obesity: NR Smoking: NR	COVID-19 severity: NR ICU admission: 14.4% (150/1039) Mechanical ventilation: NR Length of hospital stay (days, median): 7 Time post-hospital: 0 days (discharge)	Discharge disposition
Wang, 2020[55] China Prospective cohort Funding: Government	Inclusion: Confirmed COVID-19 patients discharged from hospital Exclusion: Could not be contacted or refused to participate	N=131 Age (years, median): Non-severe: 38; Severe: 60 (P<.0) Gender (% male): 45 Race: NR Comorbidities: CVD: NR CKD: NR COPD: NR DM: 2% HTN: 3% Obesity: NR Smoking: NR	COVID-19 severity: 53% (69/131) severe ICU admission: NR (NOTE: "severe" category did not require ICU admission) Mechanical ventilation: NR Length of hospital stay (median): 15 days Time post-hospital: 7 to 28 days	SARS-CoV-2 status Complete blood count Chest CT Readmission Post-discharge treatments
Xu, 2020[56] China	Inclusion: Adults with confirmed SARS-CoV-2 infections (RT-PCR); critically ill (admitted to ICU, requiring mechanical	N=92 (survivors; data from 147 non-survivors not reported here) Age (years, mean): 58 Gender (% male): 58	COVID-19 severity: 100% critically ill ICU admission: 100%	Oxygen therapy post-discharge 60-day mortality

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
Retrospective case series Funding: Government	ventilation or fraction of inspired oxygen concentration ≥60%) Exclusion: Deceased within 48 hours after ICU admission	Race: NR Comorbidities: CVD: 15% CKD: NR COPD: 3% DM: 20% HTN: 45% Obesity: NR Smoking: NR	Mechanical ventilation: 50% Length of hospital stay: NR Time post-hospital: NR (followed to 60 days from admission)	
Yan, 2020[57] China Retrospective Funding: Program of Human Science and Technology Department	Inclusion: Confirmed SARS-CoV-2 (RT-PCR) Exclusion: Suspected patients with negative results after multiple tests during hospitalization	N=218 Age (years, median): 43 Gender (% male): 56 Race: NR Comorbidities: CVD: 17% CKD: 2% COPD: 6% DM: 12% HTN: NR Obesity: NR Smoking: 11% Current	COVID-19 severity: 6% critical, 11% severe, 67% moderate, 5% mild, 11% asymptomatic ICU admission: 11% of the severe and critical patients Mechanical ventilation: 7% Length of hospital stay (days, mean): 12.2 (for 217 discharged patients) Time post-hospital: unclear; quarantined for 14 days; asked to return every 2-4 weeks	“Re-positive” for SARS-CoV-2
You, 2020[58] China Case series Funding: None	Inclusion: Laboratory confirmed COVID-19; pulmonary function test after discharge from hospital Exclusion: None reported	N=18 Age (years, mean): 51 Gender (% male): 56 Race: NR Comorbidities: CVD: NR CKD: NR COPD: NR DM: 6%	COVID-19 severity: 67% (12/18) moderate, 28% (5/18) severe, 6% (1/18) critical ICU admission: NR Mechanical ventilation: NR Length of hospital stay (mean): 28 days	Lung volume Pulmonary ventilation function Ventilation impairment CT changes

Author, Year Country Study Design Funding	Inclusion/Exclusion Criteria	Baseline Demographic Data	Hospitalization Characteristics Time of Post-hospital Follow-up	Outcomes Reported and Method of Assessment
		HTN: 17% Obesity: NR Smoking: NR	Time post-hospital (mean, SD): 38 (13) days (to pulmonary function test)	
Yu, 2020[59] China Retrospective case series Funding: Government	Inclusion: COVID-19 positive confirmed by pharyngeal swab nucleic acid testing; hospitalized then discharged after treatment; underwent thin-section chest CT scans at least twice while hospitalized and at least once following discharge Exclusion: None reported	N=32 (n=14 fibrosis group, n=18; non-fibrosis group) Age (years, medians): fibrosis group 54; non-fibrosis group 37; P=.008 Gender (% male): 69 Race: NR Comorbidities: CVD: 6% CKD: NR COPD: 3% DM: 6% HTN: 13% Obesity: NR Smoking: NR	COVID-19 severity: NR ICU admission: fibrosis group 35.7% (5/14); non-fibrosis group 0% (0/18); P=.01 Mechanical ventilation: NR Length of hospital stay (medians): fibrosis group 19.5 days; non-fibrosis group 10.0 days; P=.001 Time post-hospital (median [IQR]): fibrosis group 9 [7-11] days; non-fibrosis group 9 [7.8-11.3] days	Pulmonary fibrosis via thin-section CT scan at the end of full inspirations Pulmonary fibrosis defined as a combination of parenchymal bands, irregular interfaces, coarse reticular pattern, and traction bronchiectasis

AKI=acute kidney injury; ARDS=acute respiratory distress syndrome; CAD=coronary artery disease; CMR=cardiovascular magnetic resonance; COVID-19, SARS-CoV-2: 2019 novel coronavirus; CPAP=continuous positive airway pressure; CT=computed tomography; CVD=cardiovascular disease: CKD=chronic kidney disease; COPD=chronic obstructive pulmonary disease; DM=diabetes mellitus; HTN=hypertension; IQR=interquartile range; KRT=kidney replacement therapy; MRI=magnetic resonance imaging; PE=pulmonary embolism; POCUS=point-of-care ultrasound; RT-PCR: reverse transcriptase polymerase chain reaction; VTE=venous thromboembolism

Table 2. Study Quality Appraisal

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Al Kasab, 2020[21] USA, South America, Europe Prospective	Consecutive patients meeting eligibility criteria	Multisite; n=13	Unclear how modified Rankin Scale was administered	Yes	No information about comorbidities; little information about hospitalization
Alharthy, 2020[22] Saudi Arabia Prospective	Unclear if consecutive patients	Single site; n=89	Unclear how ultrasound was analyzed	Unclear – used point-of-care ultrasound (noted limited evidence supporting its diagnostic utility in COVID-19)	Unclear how subjects were identified for enrollment; limited patient information
Atalla, 2020[60] USA Retrospective	Unclear if all patients were reviewed for eligibility	2 sites; n=339 (19 readmitted)	Only captured patients who presented to hospital they were discharged from	Medical records and post-discharge call to patients	Yes
Benussi, 2020[23] Italy Retrospective cohort	Included all patients meeting eligibility criteria	Single site (“hub” for acute cerebrovascular diseases); n=56 with COVID-19	Unclear how Stroke Scale was administered	Unclear how stroke was diagnosed; NIH Stroke Scale for assessment	Yes
Casas-Rojo, 2020[38] Spain Retrospective cohort	Consecutive patients	150 hospitals in registry; n=15,111	Unclear how patients were followed for readmission data; unclear if patients may have presented to other hospitals	Electronic data capture system with procedures for verification of data	Yes
Chan, 2020[24] USA Retrospective	Unclear if consecutive patients	5 sites; n=3993 (1835 with AKI while hospitalized; 212 with post-discharge follow-up)	Unclear – AKI defined based on change from baseline creatinine; 63% had missing data and creatinine was imputed; used creatinine from 7 to 365 days prior to admission for others	Yes - dataset	No patient characteristics for the n=212 patients with post-discharge follow-up data

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Collins, 2020[25] USA Retrospective	All patients reviewed for eligibility	3 sites; n=20	Yes	Electronic medical records	Yes
Curci, 2020[26] Italy Cross-sectional	Consecutive patients reviewed for eligibility; all eligible included	Single site; n=32	Yes	No spirometry measures	Yes
Dennis, 2020[39] United Kingdom Preprint Prospective	Unclear if consecutive patients; described population as “low-risk” (*eg*, younger, largely without risk factors, pre-existing disease, or hospitalization) but inclusion criteria don’t require that	2 sites; n=37 hospitalized (of n=201 included)	Unclear whether MRI was dual-reviewed; unclear how questionnaires were administered	Validated questionnaires (patient-reported), blood tests, MRI	Unclear how subjects were identified for enrollment
Egol, 2020[40] USA Prospective	Consecutive patients	7 hospitals served by a university orthopedic department; n=17	Unclear how patients were followed after discharge	Unclear – source of data not reported	Unclear how many were COVID-19 positive at admission vs during admission
El Moheb, 2020[41] USA Retrospective	All patients meeting eligibility criteria identified; report focused on 141 of 242 (58%) with COVID-19 whose gastrointestinal complications while hospitalized were previously reported; after propensity matching, 92 COVID-19 patients were included	Single site with 13 ICUs; n=92	Unclear – length of follow-up for emergency department readmission not reported	Unclear – source of data not reported	No information about patient disposition at discharge, post-discharge monitoring, or length of follow-up
Fisher, 2020[27] USA Retrospective	Unclear whether age 18 was included or excluded; not specified if all patients were reviewed for eligibility	3 hospitals in a healthcare system; n=3,345	Yes	Medical records	Disposition of all patients is unclear

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Frija-Masson, 2020[42] France Retrospective	Unclear if all patients were reviewed for eligibility	Single site; n=50	Yes	Did not perform CT measures at 30 days	Unclear how 30 days post-symptom onset relates to time post-discharge
Fuglebjerg, 2020[28] Denmark Case series	Consecutive patients reviewed for eligibility; all eligible included	Single site; n=26	Yes	Authors note that clinical implications of hypoxia are not well describe in the literature	Little information about patients (eg, comorbid conditions, COVID severity)
Garrigues, 2020[43] France Prospective, survey	Contacted all eligible patients	Single site, n=120	Telephone questionnaire administered by trained physicians	Some elements of questionnaire were developed by the study authors	Limited information
Goicoechea, 2020[29] Spain Retrospective	All admitted patients on maintenance hemodialysis meeting eligibility criteria	Single site; n=36	No information	Unclear (“worsening or appearance of X-ray pulmonary infiltrates”)	No information about patients who were discharged
Grewal, 2020[30] USA Retrospective	All patients admitted meeting eligibility criteria	Single site; n=13	Yes	Yes	Little information about hospitalization (*eg,* ICU admission, ventilation)
Hong, 2020[44] China Cross-sectional	All admitted patients meeting eligibility criteria	2 sites; n=29 (subgroup followed after discharge)	Unclear if all patients received follow-up tests for COVID-19	Yes	Little information on follow-up subgroup and unclear whether follow-up was until or after discharge
Huang L, 2020[45] China Retrospective	Consecutive patients meeting eligibility criteria	Single site; n=26	Yes	Yes	No information on time post-discharge
Huang Y, 2020[46] China Retrospective	Unclear if all patients were reviewed for eligibility	Single site; n=57	19% (13/70) eligible could not be contacted or declined participation	Yes	Little information about ICU and mechanical ventilation while hospitalized

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Katz, 2020[31] USA Retrospective	All patients meeting eligibility criteria	11 hospitals in a health system; n=86	Yes	Yes – chart review and other databases	Yes
Knights, 2020[61] United Kingdom Retrospective	All admitted patients	Single site; n=69 (survivors)	Unclear how post-discharge care needs were captured	Data from electronic and paper medical records; additional information from patients	No information about patients discharged to care home or other
Liotta, 2020[32] USA Retrospective	Consecutive patients	10 hospitals in a health system; n=509	Modified Rankin Scale scores determined independently by 2 reviewers	Data from electronic medical records (including templates specific to COVID-19), clinical notes, diagnostic studies, and physician-documented diagnoses; modified Rankin Scale	Yes
Lovinsky-Desir, 2020[47] USA Retrospective	Sequential patients	2 hospitals in network; n=1243 (n=95 in <21 age group not included - median age 14-15)	Unclear how patients were followed for readmission data	Yes – medical records	Length of follow-up for readmission unclear
Mo, 2020[33] China Retrospective	Unclear if all patients were reviewed for eligibility	Unclear if single site; n=110	Yes	Lung function tests but no imaging	Yes
Ng, 2020[34] USA Retrospective Pre-proof	All admitted patients meeting eligibility criteria	13 hospitals in a health system; n=3,854 (2,771 survivors)	Yes	Data from chart reviews (hospital progress, discharge, and social worker notes)	Yes
Ntaios, 2020[35] Multi-national Retrospective	Consecutive patients meeting eligibility criteria	28 sites in 16 countries; n=174 (96 survivors)	Unclear how modified Rankin Scale was administered	Global COVID-19 Stroke registry	Yes
Patell, 2020[48] USA Retrospective	Consecutive patients meeting eligibility criteria	Single site; n=163	Unclear if all patients were followed	Medical records	Yes

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Paterson, 2020[36] United Kingdom Retrospective	Cases referred to COVID team meetings ("selective")	Single site; n=43 (29 with definite COVID-19)	Unclear	Unclear – little information about source of data	Yes
Puntmann, 2020[49] Germany Prospective	Unselected cohort	Single site; n=100	Yes	Yes	Little information about hospitalized patients vs home recovery
Richardson, 2020[50] USA Case series	All admitted patients meeting eligibility criteria	12 sites; n=5,700	Authors note median follow-up of 4.4 days post-discharge	Yes – electronic medical records	Little information on patients who were discharged
Roberts, 2020[51] United Kingdom Prospective	All events at designated sites (patients may have presented elsewhere during follow-up)	2 sites of 1 hospital	No routine contact during follow-up (only captured patients who presented to hospital they were discharged from)	Yes - imaging required	No patient demographic data
Sachdeva, 2020[52] USA Retrospective	All patients meeting eligibility criteria	13 hospitals of a health system; n=11	Unclear – methods for obtaining follow-up information not specified; unclear if patients may have presented to other hospitals	Yes – electronic and manual chart review	Length of follow-up not reported
Somani, 2000[53] USA Retrospective	Unclear if all patients were reviewed for eligibility	5 hospitals of a health system; n=103	No systematic follow-up; unclear if patients may have presented to other hospitals	Yes – electronic health records	Yes
Suleyman, 2020[62] USA Retrospective case series	Consecutive patients	5 sites; n=355 hospitalized patients	Follow-up to 30 days post-discharge	Yes – electronic medical records	Yes
Tian, 2020[54] China Retrospective	All patients who were discharged	Multiple hospitals; n=20 "re-positive' cases	Patients were discharged to designated locations for isolation and monitoring	RT-PCR testing; frequency of testing not reported	No information on protocol for monitoring

Author, Year Country Study Design	Clear Inclusion Criteria/Consecutive/ Complete?	Adequate Sample Size?	Condition/Outcome Measured in a Standard Reliable Way?	Valid Methods for Identification of the Condition/Outcome?	Adequate Information about Subjects & Setting?
Vizcaychipi, 2020[37] United Kingdom Prospective	Consecutive admissions evaluated for eligibility	2 hospitals of 1 institution; n=939	Source of disposition data not reported	Unclear	No information on COVID-19 severity
Wang, 2020[55] China Prospective cohort	Unclear if all patients were reviewed for eligibility	Single site; n=131	Followed every 7 days up to 4 weeks; methods for follow-up data collection unclear	Data obtained by questionnaire	Yes
Xu, 2020[56] China Retrospective case series	Unclear if all patients were reviewed for eligibility	3 sites; n=239 ICU patients	Unclear if follow-up was complete for post-discharge patients	Self-report	Yes
Yan, 2020[57] China Retrospective	Unclear if all patients were reviewed for eligibility	3 hospitals; n=218	After discharge, patients were required to quarantine and monitor their health for 14 days; requested to return to hospital for follow-up exams every 2-4 weeks	Data source not reported	Unclear how many patients complied with requested follow-up
You, 2020[58] China Case series	Unclear if study included all or consecutive patients	Single site; n=18	Yes	CT scans not completed at the same time as pulmonary function tests; CT scans reviewed independently by 2 cardiothoracic radiologists blinded to clinical information	Yes
Yu, 2020[59] China Retrospective case series	Unclear if study included all patients	Single site; n=32	Specific criteria provided for many of the outcomes assessed from the CT scan	CT scans reviewed independently by 3 experienced radiologists	Yes

CT=computed tomography; MRI=magnetic resonance imaging
Reference: JBI Critical Appraisal Checklist for Case Series

Table 3. Pulmonary Outcomes

Author, Year Country Study Design	Pulmonary Fibrosis % (n/N)	Lung Volume	Diffusion Capacity	Other
Alharthy, 2020[22] Saudi Arabia Prospective	NR	NR	NR	**Pleural Effusions at Discharge** 1.5% (1/64) (n=64 survivors)
Curci, 2020[26] Italy Cross-sectional	NR	NR	NR	**PaO_2/FiO_2 (mmHg)** Mild alteration (300-399): 22% (7/32) Moderate alteration (200-299): 38% (12/32) Severe alteration (<200): 41% (13/32) **Respiratory Supports Needed** None: 13% (4/32) Nasal cannula: 41% (13/32) Oxygen mask: 13% (4/32) Venturi mask: 25% (8/32) Non-rebreather mask: 9% (3/32) **mMRC Dyspnea Scale** Grade 4: 13% (4/32) Grade 5: 88% (28/32)
Dennis, 2020[39] United Kingdom Prospective PREPRINT	NR	NR	NR	**Deep Breathing Fractional Area Change <39%** 47% (16/34) (n=3 missing data)
Frija-Masson, 2020[42] France Retrospective	NR	NR	**Pulmonary Function Test Interpretation** Normal: 48% (24/50) Restrictive pattern: 8% (4/50) Restriction with altered diffusion capacity: 18% (9/50) Altered diffusion capacity only: 26% (13/50)	NR
Fuglebjerg, 2020[28] Denmark Case series	NR	NR	NR	**Exercise-Induced Hypoxia, % (n/N)** 50% (13/26) NOTE: PE confirmed in 67% (4/6) who underwent further testing

Author, Year Country Study Design	Pulmonary Fibrosis % (n/N)	Lung Volume	Diffusion Capacity	Other
				SpO_2 <90% was not associated with an increase in subjective dyspnea (Borg scale)
Garrigues, 2020[43] France Prospective, survey	NR	NR	NR	**mMRC Dyspnea Scale Grade 2 or More** 29% (35/120) Ward patients: 28% (27/96) ICU patients: 33% (8/24)
Goicoechea, 2020[29] Spain Retrospective	NR	NR	NR	**"Lung Abnormalities"** 86% (6/7) (Worsening or appearance of X-ray pulmonary infiltrates)
Huang Y, 2020[46] China Retrospective	7% (4/57)	**FEV_1 <80% Predicted** 9% (5/57) (mild impairment) **FVC<80% Predicted** 11% (6/57) (5 mild impairment, 1 moderate) **FEV_1/FVC <80%** 44% (25/57) (mild impairment) **TLC <80% of Predicted** 12% (7/57) (6 mild, 1 moderate) Outcomes did not differ by severity of COVID-19	**DLCO <80% Predicted** 53% (30/57) (26 mild impairment, 4 moderate) Subgroups Severe COVID-19: 77% (13/17) Non-severe: 43% (17/40) P=.02	**Respiratory Muscle Strength** Pimax <80% Predicted 49% (28/57) Pemax <80% Predicted 23% (13/57) **CT Residual Abnormality** 54% (31/57) Subgroups Severe COVID-19: 94% (16/17) Non-severe: 38% (15/40) P Not Reported **Obstructive Pulmonary Dysfunction** 11% (6/57) **Restrictive Pulmonary Function** 12% (7/57) **Combined Obstructive and Restrictive** 4% (2/57)
Mo, 2020[33] China Cross-sectional	NR	**FEV_1 <80% Predicted** 14% (15/110) **FVC <80% Predicted** 9% (10/110)	**DLCO <80% Predicted** 47% (51/110) COVID-19 Severity Subgroups	NR

Author, Year Country Study Design	Pulmonary Fibrosis % (n/N)	Lung Volume	Diffusion Capacity	Other
		FEV_1/FVC <70% 5% (5/110) Outcomes above did not differ by severity of COVID-19 **TLC <80% Predicted** 25% (27/110) COVID-19 Severity Subgroups Mild: 17% (4/24) Pneumonia: 21% (14/67) Severe Pneumonia: 47% (9/19) P<.05 overall and for Severe Pneumonia vs Pneumonia or vs Mild	Mild: 30% (7/24) Pneumonia: 42% (28/67) Severe Pneumonia: 84% (16/19) P=.001 overall P<.01 for Severe Pneumonia vs Pneumonia or vs Mild	
Wang, 2020[55] China Prospective cohort	NR	NR	NR	**Chest CT deteriorated** 1-2 weeks post-discharge 5.6% (2/36) (1 with enhanced inflammatory infiltrates, 1 with multiple bilateral GGO) 3-4 weeks post-discharge 0% (0/54) Outcomes did not differ by severity of COVID-19
You, 2020[58] China Case Series	Pulmonary fibrosis: 22% (4/18) GGO plus pulmonary fibrosis: 61% (11/18) Normal: 6% (1/18) Not available: 11% (2/18)	**VC_{max} <80% Predicted** 17% (3/18) **FEV_1 <80% Predicted** 17% (3/18) **FVC <80% Predicted** 17% (3/18) **FEV_1/FVC <70%** 17% (3/18) Outcomes did not differ by severity of COVID-19	NR	**Ventilation Impairment** Normal: 67% (12/18) Obstructive Ventilatory Impairment: 17% (3/18) Restrictive Ventilatory Impairment: 17% (3/18)
Yu, 2020[59] China	44% (14/32)	NR	NR	NR

Author, Year Country Study Design	Pulmonary Fibrosis % (n/N)	Lung Volume	Diffusion Capacity	Other
Retrospective case series				

DLCO=diffusing capacity of the lung for carbon monoxide; FEV_1 =forced expiratory volume in 1 sec; FVC=forced vital capacity; GGO=ground-glass opacity; mMRC=modified Medical Research Council; NR=not reported; PE=pulmonary embolism; TLC=total lung capacity

Table 4. Cardiovascular Outcomes

Author, Year Country Study Design	Cardiac Magnetic Resonance Imaging	Blood Tests	Other
Alharthy, 2020[22] Saudi Arabia Prospective	NR	NR	**Pericardial Effusion (Ultrasound) at Discharge** 1.5% (1/64) (n=64 survivors)
Dennis, 2020[39] United Kingdom Prospective PREPRINT	**Left Ventricular Ejection Fraction (%)** Normal (>55%): 70% (26/37) Borderline impairment (50-55%): 19% (7/37) Definite impairment (<50%): 11% (4/37) **Evidence of Myocarditis** 11% (4/37)	NR	NR
Huang L, 2020[45] China Retrospective NOTE: of 26 patients tested, 15 (58%) were considered positive based on presence of positive conventional CMR findings (increased myocardial edema ratio [>2.0] (n=7) and/or LGE presence (n=8)) and 11 (42%) were negative	**Myocardial Edema** 54% (14/26) 50% (7/14) with positive LGE 50% (7/14) with small pericardial effusion **LGE** 31% (8/26) with focal linear subepicardial and patchy mid-wall LGE Native T1, T2, and ECV values were significantly elevated in recovered COVID-19 patients with positive CMR findings compared with healthy controls Right ventricular ejection fraction, cardiac index, and stroke volume area were decreased in recovered COVID-19 patients with positive CMR findings compared with healthy controls	NR	NR
Puntmann, 2020[49] Germany Prospective	**Abnormal Native T1** COVID-19: 78% (73/100) Healthy Controls: 6% (3/50) Risk Factor-matched Controls: 40% (23/57) **Abnormal Native T2:**	**Detectable hsTNT (≥3 pg/mL)** COVID-19: 71% (71/100) Healthy Controls: 22% (11/50) Risk Factor-matched Controls: 57% (31/57) P<.05 for COVID-19 vs Controls	NR

NOTE: Data for 100 patients; 33% hospitalized	COVID-19: 60% (60/100) Healthy Controls: 4% (2/50) Risk Factor-matched Controls: 9% (5/57) **LGE** *Myocardial* COVID-19: 32% (32/100) Healthy Controls: 0% Risk Factor-matched Controls: 17% (9/57) *Pericardial* COVID-19: 22% (22/100) Healthy Controls: 0% Risk Factor-matched Controls: 15% (8/57) **Pericardial Effusion >10 mm** **COVID-19:** 20% (20/100) Healthy Controls: 0% Risk Factor-matched Controls: 15% (8/57) **All measures:** P<.05 for COVID-19 vs Controls	**Significantly elevated hsTNT (≥13.9 pg/mL)** COVID-19: 5% (5/100) Healthy Controls: 0% Risk Factor-matched Controls: 0% P<.05 for COVID-19 vs Controls	

hsTNT=high-sensitivity Troponin T; LGE=late gadolinium enhancement

Table 5. Neurological Outcomes

Author, Year Country Study Design	NIH Stroke Scale	Modified Rankin Scale	Other
Al Kasab, 2020[21] USA, South America, Europe Prospective	NR	**"Functional Independence on Discharge"** **Score 0-2** 17% (2/12) NOTE: missing data for n=1 Non-COVID-19 group 30% (94/316) P=.52 NOTE: missing data for n=129	NR
Benussi, 2020[23] Italy Retrospective cohort	Median (IQR) COVID-19 group (n=43) 9.0 (1.0-19.0) Non-COVID-19 group (n=68) 2.0 (0.0-6.8) P=.005	**"Good Outcome"** **Score ≤2 at Discharge** COVID-19 group: 25.6% (11/43) Non-COVID-19 group: 70.6% (48/68) P<.001	NR
Garrigues, 2020[43] France Prospective, survey	NR	NR	**Attention Disorder** 27% (32/120) Ward patients: 29% (28/96) ICU patients: 17% (4/24) P=.327 **Memory Loss** 34% (41/120) Ward patients: 38% (36/96) ICU patients: 21% (5/24) P=.194
Grewal, 2020[30] USA Retrospective	Median (IQR) COVID-19 group (n=13) 11 (4-23) 2020 Comparison Cohort: 3 (2-13) 2019 Comparison Cohort: 4 (1-11)	**"Poor Outcome"** **Score >2 at Discharge** COVID-19 group: 77% (10/13) 2020 Comparison Cohort: 47% (25/53) 2019 Comparison Cohort: 41% (36/88)	NR

Author, Year Country Study Design	NIH Stroke Scale	Modified Rankin Scale	Other
Liotta, 2020[32] USA Retrospective	NR	**Score ≤2 at Discharge** Overall: 71.1% (362/509) No neurological manifestation (during hospitalization): 70.0% (63/419) Any neurological manifestation: 71.4 (299/419) No encephalopathy (during hospitalization): 89.3% (310/347) Encephalopathy: 32.1% (52/162)	
Ntaios, 2020[35] Multi-national registry Retrospective	NR	**Severe Disability at Discharge** COVID-19 group: 51% (49/96 survivors) **Median Score (propensity matched population (n=330)** COVID-19 group: 4 [IQR 2-6] Matched group: 2 [IQR 1-4] P<.001	NR

Table 6. Renal Outcomes

Author, Year Country Study Design	Acute Kidney Disease	Imaging Findings	Need for Kidney Replacement Therapy
Chan, 2020[24] USA Retrospective	**At Discharge** 35% (291/832)* AKD Stage 1: 23% AKD Stage 2: 6% AKD Stage 3: 6% **Follow-up (median 21 [IQR 8-38] days)** Data available for n=77 with AKD at discharge Recovered: 36% (28/77) AKD Stage 1: 33% (25/77) AKD Stage 2: 13% (10/77) AKD Stage 3: 18% (14/77) Data available for n=135 who had recovered at discharge Remain recovered: 86% (116/135) New AKD Stage 1: 10% (14/135) New AKD Stage 2: 2% (3/135) New AKD Stage 3: 2% (3/135)	NR	
Dennis, 2020[39] United Kingdom Prospective PREPRINT	NR	**Kidney Cortex T1** Normal: 78% (29/37) Definite Impairment: 22% (8/37)	
Ng, 2020[34] USA Retrospective Pre-proof	**At Discharge** **KRT** 17% (108/638) survived; 33% (36/108) had not recovered kidney function **Non-KRT** 52% (1663/3216) survived; 26% (430/1663) had not recovered kidney function	NR	**KRT** 92% (33/36) who had not recovered needed KRT at discharge (30.6% [33/108] of survivors who required hospital KRT) NOTE: 58% (19/33) had underlying CKD on admission

AKD=acute kidney disease; CKD=chronic kidney disease; IQR=interquartile range; KRT=kidney replacement therapy
*Of 1835 with AKI while hospitalized, 832 were discharged; 291 with acute kidney disease

Table 7. Gastrointestinal Outcomes

Author, Year Country Study Design	Imaging Findings
Dennis, 2020[39] United Kingdom Prospective PREPRINT	**Liver Inflammation (cT1 in ms)** Normal (<800 ms): 84% (31/37) Borderline (800-825 ms): 0% (0/37) Significant (>825 ms): 16% (6/37)

Table 8. Hematologic Outcomes

Author, Year Country Study Design	Thromboembolism	Hemorrhage
Alharthy, 2020[22] Saudi Arabia Prospective	**DVT at Discharge** 12.5% (8/64) (n=64 survivors)	NR
Patell, 2020[48] USA Retrospective	2.5% (4/163) at median of 23 days [IQR 12-33] 1 each: PE, intracardiac thrombus, thrombosed arteriovenous fistula, ischemic stroke Among 13 patients discharged on thromboprophylaxis: no observed thrombotic or hemorrhagic complications	3.7% (6/163) at median of 27 days [IQR 16-31] 2 “major bleeds” (both following falls), 4 “clinically relevant non-major bleeding”
Roberts, 2020[51] United Kingdom Prospective	**VTE** COVID-19 Cohort 0.48% (9/1877) at median of 8 days [range 3-33] 2 DVT, 7 PE Comparison Cohort (Medical Admissions in 2019) 0.31% (56/18,159) 8 proximal, 10 distal, 5 line-associated upper-limb DVT, 33 PE OR 1.6 (95%CI 0.77, 3.1); P=.2	NR

DVT=deep venous thrombosis; IQR=interquartile range; PE=pulmonary embolism

Table 9. Healthcare/Resource Utilization Outcomes

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
Atalla, 2020[60] USA Retrospective	**On Readmission** 63% (12/19)	5.6% (19/339) Median of 5 days {IQR 3-13] post discharge **Clinical Course During 2nd Admission** Length of Stay: 7 days Intensive Care: 31% NOTE: 3 patients required a third admission	**For 19 Patients Readmitted** Skilled Nursing Facility: 26% (5/19) Home (n=11) or Hotel for COVID+Homeless (n=3): 74% (14/19)	NR	**Reasons for Readmission** Bacterial pneumonia secondary to COVID-19 infection: 21% (4/19) Prolonged COVID-19 Course: 21% (4/19) Psychiatric episodes: 16% (3/19) Metabolic encephalopathy: 11% (2/19) Thrombotic episodes: 11% (2/19) Alcohol intoxication, orthostatic hypotension, gastroenteritis, fall/trauma (1 each): 21% (4/19)
Casas-Rojo, 2020[38] Spain Retrospective cohort	NR	3.9% (573/14,709) Of patients discharged: 4.8% (573/11,928) Not discharged at end of follow-up (after readmission) 0.2% (31/15,150) Of patients readmitted: 5.4% (31/573)	NR	NR	NR
Collins, 2020[25] USA Retrospective	NR	NR	Home: 65% (13/20) or 81% (13/16 discharged) Nursing facility (permanent residence): 5% (1/20) or 6% (1/16 discharged) Hotel for those with confirmed COVID-19: 10% (2/20) or 13% (2/16 discharged)	NR	NR

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
Egol, 2020[40] USA Prospective	NR	**Within 30 Days** COVID-19 Positive: 11.8% (2/17) COVID-19 Suspected: 7.1% (1/14) COVID-19 Negative: 2.8% (3/107) P=.21	NR	**Post-Acute Rehabilitation** COVID-19 Positive: 90.0% (9/17) COVID-19 Suspected: 84.6% (11/14) COVID-19 Negative: 78.3% (83/107) P=.61	NR
El Moheb, 2020[41] USA Retrospective	NR	**Emergency Department Readmission** 11% (10/92) Matched comparison group of non-COVID-19 ARDS patients: 11% (10/92) Length of follow-up not reported	NR	NR	NR
Fisher, 2020[27] USA Retrospective	NR	NR	**Nursing Home** COVID-19 positive: 14.7% (492/3345) or 23% (492/2142 discharged) COVID-19 negative: 12.8% (152/1265) or 17% (162/950 discharged) RR (total study population): 1.2 (95%CI 1.0, 1.4) Historical control: 14.6% (1436/9859) or 15% (1436/9544 discharged) RR (COVID positive vs control, total study population): 1.0 (95%CI 0.9, 1.1)	NR	NR

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
			Home COVID-19 positive: 49.3% (1650/3345) or 77% (1650/2142 discharged) COVID-19 negative: 62.3% (788/2365) or 83% (788/950 discharged) RR (total study population): 0.08 (95%CI 0.7, 0.8) Historical control: 82,2% (8108/9859) or 85% (8108/9544 discharged) RR (COVID positive vs control, total study population): 0.6 (95%CI 0.57, 0.62)		
Grewal, 2020[30] USA Retrospective	NR	NR	Disposition reported for 10/13 survivors (remaining patients: 2 deaths, 1 unknown disposition) Home: 30% (3/10) (2/6 in 'COVID' group, 1/4 in 'Neuro' group) Acute rehabilitation: 50% (5/10) (3/6 in 'COVID' group, 2/4 in 'Neuro' group) Long-term acute care: 20% (2/10) (1/6 in 'COVID' group, 1/4 in 'Neuro' group)	NR	NR
Hong, 2020[44] China Retrospective	28% (8/29)	NR	NR	NR	NR
Katz, 2020[31] USA Retrospective	NR	NR	COVID-19 group Home: 29% (25/86) or 45% (25/56 discharged) Rehabilitation: 36% (31/86) or 55% (31/56 discharged)	NR	NR

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
			(Additional 30 patients died or in hospice care) Non-COVID-19 group Home: 46% (228/499) or 52% (228/438 discharged) Rehabilitation: 42% (210/499) or 48% (210/438 discharged) (Additional 61 patients died or in hospice care) Overall P<.001		
Knights, 2020[61] United Kingdom Retrospective	NR	5.4% (3/56 patients discharged home)	Home: 81% (56/69 discharged) Care Home: 14% (10/69 discharged) Other (not specified): 4% (3/69 discharged)	New “packages of care”: 2.9% (2/69 discharged) New care home placement: 7.2% (5/69 discharged) Increase in mobility aids: 11.6% (8/69 discharged)	NR
Lovinsky-Desir, 2020[47] USA Retrospective	NR	Age 21-39 No Asthma: 5% (12/261) Asthma: 10% (4/39) P=.14 Age 40-65 No Asthma: 5% (40/832) Asthma: 5% (5/111) P=1.0	NR	NR	NR
Patell, 2020[48] USA Retrospective	NR	7% (12/163)	**NR**	NR	NR

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
Paterson, 2020[36] United Kingdom Retrospective	NR	NR	**Patients with Encephalopathy** (n=7 discharged) Home: 86% (6/7) Rehabilitation Unit: 14% (1/7) **Patients with Inflammatory Central Nervous System Syndromes** (n=2 discharged) Home: 100% (2/2) **Patients with Ischemic Stroke** (n=4 discharged) Rehabilitation Unit: 75% (3/4) Stroke Unit: 25% (1/4) **Patients with Peripheral Neurological Syndromes** (n=2 discharged; location NR **Uncharacterized Condition** (n=1 discharged to home**)**	NR	NR
Richardson, 2020[50] USA Case series	NR	Overall: 2.2% (45/2081) <18 years: 3.1% (1/32) 18-65 years: 1.6% (22/1,373) >65 years: 3.3% (22/676) **Time to Readmission** (median [IQR]) 3 [1.0, 4.5) days	**Facility (eg, nursing home, rehabilitation)** Overall: 5.9% (122/2081) <18 years: 0% (0/32) 18-65 years: 2.0% (28/1373) >65 years: 13.9% (94/676) **Home** Overall: 94.1% (1959/2081) <18 years: 100% (32/32) 18-65 years: 98% (1345/1373) >65 years: 86% (582/676)	NR	NR
Sachdeva, 2020[52] USA Retrospective	NR	9% (1/9 discharged home) Length of follow-up NR	NR	NR	NR
Somani, 2000[53]	NR	**Returned for Emergency Care**	**NR**	NR	**Reasons for Return** Respiratory distress: 50%

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
USA Retrospective		3.6% (103/2864) Median 4.5 days **Inpatient Admission** 54.4% (56/103)			Chest pain: 6% Other pain: 6% Altered mental status: 5% Falls: 5% Soft tissue infection: 5% **Need for ICU level care** 10.7% (6/56)
Suleyman, 2020[62] USA Retrospective case series	NR	**30-day Hospital** Overall: 11.2% (29 cases) General practice unit: 27 cases ICU: 2 cases P<.001 NOTE: among patients initially discharged home from ED, 4% (4/108) were readmitted within 30 days	**Home** General practice unit: 96% (183/191 with known discharge disposition) ICU: 79% (49/62 with known discharge disposition) **Rehabilitation center** General practice unit: 4% (8/191) ICU: 21% (13/62)	NR	**30-day Mortality (includes hospital mortality**) General practice unit: 7% (15/214) ICU: 40% (57/141) P<.001
Tian, 2020[54] China Retrospective	'Re-positive" RT-PCR 13.6% (20/147) Median 17.3 days post-discharge (range 7-47 days) All were asymptomatic with no progressive lesions on chest CT compared to images at first discharge 8 cases showed alternating PRC positivity and negativity				

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
Vizcaychipi, 2020[37] United Kingdom Prospective	NR	NR	**Home (usual residence)** 92.5% (614/664 discharged alive) **Temporary Home** 2.4% (16/664) **Residential Care Home** 5.1% (34/664)	NR	NR
Wang, 2020[55] China Prospective cohort	1-2 weeks post-discharge 17% (6/36) 3-4 weeks post-discharge 2.4% (2/83)	1-2 weeks post-discharge 4% (5/131) 3-4 weeks post-discharge 2% (3/131)	**Home Quarantine** 1-2 weeks post-discharge 87% (114/131) 3-4 weeks post-discharge 92% (121/131) **Community Quarantine** 1-2 weeks post-discharge 9% (12/131) 3-4 weeks post-discharge 3% (4/131) **Designated Hospital** 1-2 weeks post-discharge 4% (5/131) 3-4 weeks post-discharge 2% (3/131) **Return to Work** 1-2 weeks post-discharge 0% (0/131) 3-4 weeks post-discharge 2% (3/131) Outcomes did not differ by severity of COVID-19	**Oxygen therapy** 1-2 weeks post-discharge 7% (9/131) 3-4 weeks post-discharge 1% (1/131) **Corticosteroids** 1-2 weeks post-discharge 4% (5/131) 3-4 weeks post-discharge 2% (2/131) Outcomes did not differ by severity of COVID-19	**CBC abnormal** 1-2 weeks post-discharge 14% (2/14) 3-4 weeks post-discharge 8% (4/50) Outcomes did not differ by severity of COVID-19
Xu, 2020[56] China Retrospective case series	NR	NR	NR	**Oxygen therapy** 6% (5/85) (nasal cannula)	**60-day mortality (overall)** 62% (147/239) NOTE: Predictors included age >65, lymphocyte and platelet count, ARDS, acute cardiac

Author, Year Country Study Design	Positive SARS-CoV-2	Readmission	Discharge Disposition	Post-discharge Treatment	Other
					injury, AKI, liver dysfunction, and coagulopathy
Yan, 2020[57] China Retrospective	9% (20/218) retested positive for SARS-CoV-2 after recovery and hospital discharge (18 from moderate disease group, 2 from mild group)	NR	NR	NR	NR

ARDS=acute respiratory distress syndrome; ED=emergency department: ICU=intensive care unit; IQR=interquartile range

APPENDIX D. PRISMA CHECKLIST

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title 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.	Separate document
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	1
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.	3
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.	3-4
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
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Appendix A
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).	3
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.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3
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.	3
Summary	13	State the principal summary measures (e.g., risk ratio, difference in	3

measures		means).	
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.	3
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7 and Appendix C
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	7
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	7-17 and Appendix C
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	18
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	18
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	21
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Preface

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097