UC Davis
UC Davis Electronic Theses and Dissertations

Title

Risks of Adverse Outcomes for End-Stage Renal Disease Patients Hospitalized with COVID-19. A Retrospective Study in 5 California Medical Centers.

Permalink

https://escholarship.org/uc/item/3pw5v86j

Author

Reiterman, Marc

Publication Date

2021

Peer reviewed|Thesis/dissertation

Risks of Adverse Outcomes for End-Stage Renal Disease Patients Hospitalized with COVID-19. A Retrospective Study in 5 California Medical Centers.

By

MARC REITERMAN
DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Epidemiology

in the

OFFICE OF GRADUATE STUDIES

of the

UNIVERSITY OF CALIFORNIA

DAVIS

Approved:

_____
Edward R. Atwill, Chair

_____
Andrew I. Chin

_____
Heejung Bang

Committee in Charge

2022

i

Abstract

Since December of 2019, infection with SARS-CoV-2, the virus that causes COVID-19, has led to the most serious infectious disease pandemic since the influenza pandemic of 1918-1920. In the United States, over 49.2 million cases of COVID-19 were diagnosed from February 2020 to December 6, 2021, resulting in 788,315 deaths. In the state of California, over 5.1 million cases of COVID-19 were diagnosed in the same time period, resulting in 75,102 deaths and 3,562 individuals presently hospitalized. While the majority of individuals affected by COVID-19 exhibit only mild symptoms that do not require hospitalization, many require hospitalization, with the most ill patients needing intensive care unit admission, mechanical ventilation, and extracorporeal membrane oxygenation (ECMO) treatment.

End stage renal disease (ESRD) is caused when nephrons in the kidneys are damaged over time, the kidneys lose their ability to remove impurities in the blood, and kidney dialysis is required on a regular basis. Infection is the second most reported cause of death in the ESRD population. Annual death rates from pneumonia and sepsis are substantially higher among ESRD patients than among the general population. ESRD patients have a compromised and poorly regulated immune system, which may increase susceptibility to bacterial and viral infections, including the SARS-COV-2 virus. Research studies of ESRD patients who are hospitalized with Covid-19 are needed so that these patients can be risk stratified to appropriate therapeutic treatment regimens and receive the best possible in-hospital care.

A retrospective cohort study was conducted to explore 6 clinical outcomes for individuals with and without ESRD, hospitalized with Covid-19 at one of the 5 tertiary care, academic hospitals of the University of California (UC Davis, UC Irvine, UC Los Angeles, UC San Diego, and UC San Francisco). The University of California COVID Research Database (UC CORDS), a large, harmonized database provided by the UC Health Data Warehouse (UCHDW), was utilized for this purpose. In Chapter 1, logistic regression analysis was used to investigate the risks for in-hospital death and hospital length of stay of 7 days or longer. In Chapter 2, the risks of ICU admission and ICU length of stay of 7 days or longer were also explored using logistic regression analysis. In Chapter 3, Cox proportional hazards regression analysis was used to investigate the risks for death and readmission within 30 days post-hospitalization for COVID-19. Factors associated with each of the above clinical outcomes were also explored in separate analyses.

Introduction

Since December of 2019, infection with SARS-CoV-2, the virus which causes COVID-19 that

emerged in Wuhan, China has led to the most serious infectious disease pandemic since the

Spanish influenza pandemic of 1918-1920 (1). Symptoms of COVID-19 disease include: fever or

chills, cough, respiratory difficulties, fatigue, muscle or body aches, headache, new loss of taste

or smell, sore throat, congestion or runny nose, nausea or vomiting, and diarrhea. COVID-19

can lead to pulmonary, cardiac, vascular, kidney and other organ system dysfunction, with

some patients requiring hospitalization, and with the most extremely ill patients needing

intensive care unit (ICU) admission, mechanical ventilation, and extracorporeal membrane

oxygenation (ECMO) treatment.

The kidneys remove and excrete waste products of metabolism, regulate the body's

concentration of water and salts, maintain the acid-base balance of the blood, regulate blood

pressure, and secrete important hormones (2). These hormones include erythropoietin which

helps bone marrow form red blood cells, renin which stimulates formation of angiotensin in

blood and tissues, and prostaglandins which control processes such as inflammation, blood

flow, the formation of blood clots (2). The primary measure of kidney excretory function is the

glomerular filtration rate (GFR), the rate at which the kidneys filter the blood, adjusted for body

surface area. A normal GFR is > 90 mL/min per 1.74 m^2, while a GFR <90 is indicative of kidney

disease and kidney failure is defined as a GFR < 15. End-stage renal disease (ESRD) patients are

those with kidney failure who are receiving regular dialysis treatments (2).

The main causes of chronic kidney disease in the United States are diabetes (where excess glucose in the blood damages the collection of small capillaries in the kidney called glomeruli) and hypertension (where long standing high blood pressure damages the blood vessels in the kidneys). Other less common causes of chronic kidney disease include chronic glomerulonephritis (inflammatory condition oftentimes associated with chronic bacterial or viral infections), atherosclerotic renal artery stenosis and ischemic nephropathy, and gout (2).

The demographic variables age, sex, race, and ethnicity are associated with ESRD, as are heart disease; stroke; anemia, which can cause fatigue and weakness; low calcium levels and high phosphorus levels in the blood which can cause bone issues; high potassium levels in the blood which can cause an irregular or abnormal heartbeat; loss of appetite or nausea; extra fluid in the body which can cause high blood pressure, swelling in the legs, and shortness of breath; infections or weaking of the immune system; and depression (2). Individuals with ESRD may have a higher risk of serious outcomes from COVID-19, since they have higher number of comorbid conditions which are known risk factors for COVID-19, including diabetes, cardiac disease, and obesity, and a higher risk of hospitalization and mortality than individuals who do not have this disease. (2). It is therefore important to understand the additional risks for ESRD patients admitted to the hospital with COVID-19, so that these patients can be risk stratified for optimal treatment regimens when they are admitted to the hospital and perhaps a higher initial level of care. To date, there have been many studies of clinical outcomes for patients hospitalized with COVID-19, but relatively few studies of clinical outcomes for ESRD patients similarly hospitalized.

References

1. New York Times COVID-19 statistics
https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html

2. Harris, Randall E. Epidemiology of Chronic Disease pages 471-488

Chapter 1 Risks of in-hospital death and hospital length of stay of 7 days or longer for end-stage renal disease patients hospitalized with COVID-19. A retrospective cohort study in 5 California medical centers.

Introduction

Since December of 2019, infection with SARS-CoV-2, the virus which causes COVID-19, has led

to the most serious infectious disease pandemic since the influenza pandemic of 1918-1920. In

the United States, over 45.6 million cases of COVID-19 were diagnosed from February 2020 to

October27, 2021, resulting in 739,259 deaths. In the state of California, over 4.8 million cases of

COVID-19 were diagnosed in the same time period, resulting in 71,800 deaths and 4,038

patients presently hospitalized (1). While the majority of individuals affected by COVID-19

exhibit only mild symptoms that do not require hospitalization, many require hospitalization,

with the most ill patients needing intensive care unit (ICU) admission, mechanical ventilation

and extracorporeal membrane oxygenation (ECMO) treatment.

Infection is the second most commonly reported cause of death in the ESRD population (2).

Annual death rates from pneumonia and sepsis are substantially higher among ESRD patients

than among the general population (3). Patients with ESRD have a compromised and poorly

regulated immune system which may increase susceptibility to bacterial and viral infections,

including the SARS-COV-2 virus (4) .

Some studies have found that Individuals with ESRD have a higher risk of serious outcomes

from COVID-19, including a higher risk of in-hospital death (5, 6, 7, 8, 9). In a retrospective study

of 10,482 patients admitted with COVID-19 at 13 New York hospitals between March 1, 2020

through April 27, 2020, Ng *et al* (9) found a higher risk of in-hospital death and hospital stay 7

days or longer, but not for need of mechanical ventilation as a marker for higher acuity of care, in ESRD patients compared to those not on dialysis.

Other studies have found no increased risk for in-hospital mortality, and even decreased risk, for serious outcomes from COVID-19 in ESRD patients (10, 11, 12). Investigators of these studies suggested that the diminished immune system response to SARS-CoV-2 of patients with ESRD may limit the cytokine storm and systemic inflammation that can result when patients first encounter the virus (13). In their study of patients admitted with COVID-19 to the Mount Sinai Health Care System between March 15 and June 7, 2020, Chan *et al* (11) found no significant difference in in-hospital mortality between patients with kidney failure versus propensity matched patients without kidney failure (adjusted OR 0.67, 95% CI 0.33-1.38), and suggested that patients in their study had a lower prevalence of diabetes and hypertension, and may have received different clinical treatments than patients who were hospitalized later in the pandemic. In a population admitted with COVID-19 in 3 New York area hospitals between March 2 and August 27, 2020, Kahtri *et al* (12) found no difference in in-hospital mortality between ESRD patients and patients without chronic kidney disease (adjusted OR 0.79, 95% CI 0.50-1.23). Interestingly, ESRD patients in their study had significantly reduced odds of in-hospital mortality compared to non-dialysis CKD patients (adjusted OR 0.57, 95% CI 0.33 to 0.95). Finally, in their study of patients admitted with COVID-19 at a teaching hospital in the New York City metropolitan area between March 12 and May 13, 2020, Naaraayan *et al* (10) found no significant difference (adjusted OR 0.4, 95% CI 0.2-1.05) for the combined outcome of

acute respiratory distress syndrome or in-hospital death among patients with and without

ESRD.

With these contrasting findings regarding ESRD as an independent risk for a poor outcome in

hospitalizations for COVID-19, we aimed to further examine the clinical outcomes of ESRD

patients admitted for COVID-19 in a diverse Western United States population. We sought to

compare in-hospital death and hospital LOS ≥7 days in ESRD patients to that of non-ESRD

patients, in individuals admitted for COVID-19 to any of 5 tertiary care University of California

academic hospitals.

Materials and Methods

We used the University of California COVID Research Database (UC CORDS) which is a large,

harmonized database provided by the UC Health Data Warehouse (UCHDW) that includes

patients from the 5 tertiary care, academic hospitals of the University of California (UC Davis,

UC Irvine, UC Los Angeles, UC San Diego and UC San Francisco). The clinical outcomes included

the primary outcome, in-hospital death, and the secondary outcome, hospital LOS of ≥7 days.

This retrospective study included adult patients (≥18 years at time of hospital admission) with

and without ESRD, and who tested positive for COVID-19 by polymerase chain reaction nasal

swab within 30 days prior to or at any time during their hospital stay at any of the 5 University

of California medical centers. We included patients admitted between February 12, 2020 and

September 6, 2021, who were discharged alive or who died by September 7, 2021, the study

end date. Patients were classified as having ESRD if their admission included the International

Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients with an active renal transplant from the ESRD group, but included patients with failed kidney transplants who were back on long-term dialysis. See **supplemental Table S1.1** for further details.

For patients with multiple hospital admissions, only their index hospitalization associated with a positive test for COVID-19 was included in the study. Individuals were excluded from the study if they were transferred in from a hospital outside the University of California hospital system (N=556), transferred out of the University of California hospital system (N=136), admitted to an inpatient obstetric service (N=146), or were still receiving in-hospital care at the study end date.

Demographic and baseline characteristics included: age at hospital admission in years, sex, race and ethnicity. Age was categorized: 18-39 (the referent), 40-49, 50-59, 60-69, 70-79 and 80+ years. Self-reported data on race and ethnicity were combined and categorized as follows: White (White, non-Hispanic, the referent), Hispanic (White, Hispanic), Black, Asian, and Other/Unknown. In gender analyses, female was used as the referent.

Comorbid conditions identified in patients prior to or on their date of index hospital admission included: collagen vascular disease, immune system disease, including lupus, scleroderma and rheumatoid arthritis, hypothyroidism, drug use disorders, anemia, cerebrovascular disease, diabetes, hypertension, obesity, cardiac valvular disease, cardiac arrhythmias, cardiac peripheral vascular disease, major cardiac disease, HIV/AIDS, liver disease, paralysis cancer,

chronic psychoses, chronic neurological conditions, pulmonary disease, solid organ

transplantation (excluding kidney transplants) and smoking status (smoker/ever-smoker vs

never smoker). If encephalopathy, acute psychosis was diagnosed on the day of index hospital

admission, we considered these to be an acute neurological condition, acute psychosis,

respectively. We grouped asthma and chronic obstructive pulmonary disease (COPD) into a

single pulmonary disease factor. Patients were classified as having or not having these

comorbid conditions using the ICD-10-CM codes listed in **supplemental Table S1.1**. For each

comorbid condition, the absence of the condition was the referent.

Given the socioeconomic diversity of California, we also included the area deprivation index

(ADI) as a factor in our analyses. The ADI for a given neighborhood (census block group) is a

measure of relative socioeconomic disadvantage (14, 15) and is calculated by comparing

income, education, employment, and housing for that neighborhood against the mean values

of these factors for the given state (ADIs are state specific). ADIs are calculated in deciles with

an ADI of 1 signifying a neighborhood least socioeconomically disadvantaged and an ADI of 10

signifying a neighborhood which is most socioeconomically disadvantaged. Individuals in the UC

CORDS database were assigned an ADI based upon their residence zip code. In our study, 7.8%

of the ESRD patients and 16.3% of the non-ESRD patients, were missing an ADI which caused a

reduction in the sample size available for our initial analyses when ADI was considered as a

factor.

Medications administered most likely for COVID-19 treatment during the hospital stay were queried, including dexamethasone, remdesivir, oral anticoagulants and monoclonal antibodies against SARS-CoV-2. Information was also collected on the use of mechanical ventilation and extracorporeal membrane oxygenation (ECMO) treatment as indicators of disease severity, and on selective serotonin reuptake inhibitors (SSRIs) prescribed during the hospital stay.

The primary and secondary outcomes were in-hospital death and hospital LOS of ≥7 days, respectively. We utilized simple and multiple logistic regression analyses. The analyses of hospital LOS were performed only among those patients who were discharged alive. Hospital LOS was calculated as the total number of overnight stays during the hospitalization.

In addition to unadjusted models, 2 adjusted logistic regression models for in-hospital death and hospital LOS of ≥7 days were analyzed. Model 1 included the demographic variables sex, age category, and race/ethnicity. Model 2 included the demographic variables plus any comorbid conditions (confounders) which were associated at the p = 0.15 level with both the outcome and the study exposure, and which caused a ≥ 10% change in the unadjusted exposure/outcome odds ratio when added as a factor to the unadjusted logistic regression model.

Backward logistic regression models were employed to determine independent risk factors associated with in-hospital death and hospital LOS of ≥7 days among all patients. Risk factors for the demographic variables sex, age (per 10 years increase), race/ethnicity, and comorbid

conditions with odds ratios significant at the p = 0.05 level in two-sided tests were retained in each of the multivariate models.

Sample size calculations for the primary endpoint of the study, in-hospital death, were performed as follows: A logistic regression of the outcome in-hospital death on the study exposure, presence/absence of ESRD with a sample size of 5,720 observations (of which 91.5% do not have ESRD and 7.5% have ESRD) achieved 80% power at a 0.05 significance level to detect a change in the probability of in-hospital death from the baseline value of 0.090 to 0.137. This change corresponded to an odds ratio of 1.6. An adjustment was made since a multiple regression of the study exposure on the other independent variables in the logistic regression obtained an R-Squared of 0.15 (16).

This study was granted an exemption for human subjects protection by the UC Davis IRB Board (protocol# 1604619-1).

Results

After applying the study inclusion and exclusion criteria, a total of 5,761 patients were admitted to the hospital between February 12, 2020 to September 6, 2021 with a diagnosis of COVID-19 either within 30 days prior to or during their index hospitalization and were discharged alive or died during the study period. Of the 5,761 patients, 425 (7.4%) had ESRD and 5,336 (92.6%) did not have ESRD. In total, 5,260 patients (91.3%) were discharged alive, 501 (8.7%) died, with 51 (12.0%) deaths in the ESRD group and 450 (8.4%) deaths in the non-ESRD group.

The demographic and clinical characteristics for patients with and without ESRD prior to hospital admission are provided in **Table 1.1.** Patients with ESRD were more likely than those without to live in a more socioeconomically disadvantaged census tract, to self-identify as either Hispanic (56.5% vs 44.1%) or Black (13.2% vs 7.6%), to be smokers (26.6% vs 21.3%), to be obese (43.8% vs 35.3%), and to have more major comorbid conditions. The in-hospital medications and high acuity treatments administered for COVID-19 in patients by study exposure group are provided in **supplemental Table S1.2**. The baseline characteristics of patients and the medications and treatments administered to patients while hospitalized, by alive and expired status, are provided in **supplementary Table S1.3**. Compared to patients who were discharged alive, patients who expired in-hospital from COVID-19 were older (median age 73 vs 58) more likely to be male (63.9% vs 55.9%) and to self-identify as Asian (13.6% to 10.5%).

Unadjusted and multivariable-adjusted odds ratios for in-hospital death and hospital LOS of ≥7 days among patients with and without ESRD are provided in **Table 1.2**. After determining the factors to be included in our adjusted model 2 analyses, we found that compared to patients without ESRD, patients on dialysis had a significantly higher odds of in-hospital death in the unadjusted analysis (odds ratio 1.48, 95% confidence interval (95% CI) = 1.09, 2.01, p = 0.013), but this risk was not significant once it was adjusted for demographic variables and comorbid conditions (adjusted OR 0.86, 95% CI 0.61-1.22). The odds of hospital LOS of ≥7 days was also not significantly higher for those with ESRD in the adjusted analysis (adjusted OR 1.16, 95% CI 0.92-1.46).

The analyses of risk factors for in-hospital death among all patients are shown in **Table 1.3** and in **Figure 1.1**, while the analyses of risk factors for hospital LOS of ≥7 days among all patients are shown in **Table 1.4** and in **Figure 1.2**.

Discussion

In general, patients with ESRD have a worse clinical outcome with COVID-19. Using a large database that spans the 5 academic medical centers of the University of California, we sought to determine if ESRD was independently associated with a higher risk for in-hospital mortality and hospital length of stay of ≥7 days for patients diagnosed with COVID-19 with ESRD versus patients without. While we identified patient demographic and health factors that were independently linked to these 2 important outcomes, we did not find ESRD status to be one of these independent factors.

Our findings agreed with that of other studies in which ESRD status was also determined to not be independently associated with a higher risk of in-hospital mortality related to COVID-19 (10, 11, 12). The results of our study do contrast with a large study of COVID-19 hospitalizations in the State of New York by Ng *et al* (9), in which the adjusted odds of in-hospital death and hospital LOS of ≥7 days were both significantly higher for patients with ESRD compared to patients without. The differing conclusions to the risk of ESRD on COVID-19 hospitalization outcomes may be due to methodology differences in comorbid condition assessment, selection of factors into the multivariate logistic regression models or to differences in patient

population. It is also important to note that the study by Ng *et al* used a patient population with COVID-19 during the peak period of the pandemic in the Northeastern United States, during which healthcare resources, both in terms of materials as well as personnel, were limited and oftentimes in critical shortage. By many accounts, health systems at that moment were near a "crisis standard of care" (17, 18). Our study population in California was affected by the pandemic many months later and without the extreme strain on resources as experienced in New York. Thus, it is possible that the ESRD population is disproportionately affected during the most extremes of limited healthcare resources.

In our study, we identified other factors that were independently associated with higher risk for in-hospital mortality and LOS ≥7 days. We found a diagnosis of an acute neurological decline, such as acute encephalopathy, at the time of hospital admission to be one of those factors. We also found a diagnosis of acute psychoses at the time of hospital admission to be linked with higher risk for longer hospital stay. In other studies, neurological conditions have similarly been found to be associated with a poor outcome among patients hospitalized with COVID-19. Eskandar *et al* found altered mentation and acute stroke on admission to be significantly associated with higher risk of in-hospital death, independent of other comorbid conditions (19).

In contrast we observed non-renal solid organ transplantation to be significantly negatively associated with hospital LOS of ≥7 days. We surmise that clinicians may more quickly discharge transplant patients who are generally more susceptible to hospital-acquired infections. It is also

possible that patients with non-renal solid organ transplants may have more stable support at home or more resources to continue home-based care upon hospital discharge.

The strengths of this study include its large cohort size and the extensive geographical and population range covered by the 5 academic medical centers. We likewise included an extensive number of comorbid conditions, including acute neurological conditions and coagulopathy, and we were able to capture the key therapeutics used to treat COVID-19 patients.

Like all studies of this kind, the retrospective nature is a limitation. Additional limitations include comorbidity ascertainment was made by diagnostic codes, with their varied degree of accuracy and completeness, which we were not able to validate with chart review due to the pseudonymized nature of the dataset. Additionally, this study spans many months through the pandemic, and patient care management with increased experience with COVID-19 care may have changed clinical practices over time, possibly resulting in aggregation bias. The wider availability and use of COVID-19 vaccines over the study period could also conceivably have contributed to aggregation bias. Given the nature of the UC CORDS database, it was also not possible to study some key patient-level variables, including COVID-19 symptoms, blood type, vaccination status, as well as personal health habits such as masking, hand washing and social distancing practices, all which might have affected outcomes for hospitalized patients.

It is likely that research into the effects of COVID-19 among individuals with ESRD will continue to remain important for some time, since although many of these individuals have been

vaccinated against SARS-CoV-2, many others are opposed to being vaccinated. As of October

27, 2021 69% of adults in the United States have been fully vaccinated, while 31% have not (1),

and it is estimated that 25% of all US adults will continue to refuse all vaccines for COVID-19

over the long term (20). The widespread presence of the delta variant of SARS-COV-2 in the

United States has led to substantially higher rates of hospital admission for COVID-19. In a

recently published article, Twohig et al (21) found that the hazard of hospitalization among

those with the delta variant of SARS-COV-2 (B.1.617.2) was significantly higher than among

those with the alpha variant of this virus (B.1.1.7) (hazard ratio 2.26, CI 1.32-3.89). It therefore

appears likely that COVID-19 will become an endemic disease in the US, and that many

individuals will continue to require hospitalization for this disease, including those with ESRD.

Patients with ESRD have many of the comorbid conditions linked with a worse outcome from

COVID-19 hospitalization. Despite the immune system compromise of patients with ESRD, we

did not find upon adjusting for demographic variables and comorbid conditions that presence

of ESRD was independently associated with a higher risk for in-hospital death or LOS ≥7 days. As

clinicians, we need to continue to advocate for optimal COVID-19 hospital care of this

population.

References
1. New York Times COVID-19 statistics
https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html

2. Harris, Randall E. Epidemiology of Chronic Disease pages 471-488

3. Jaber BL Bacterial infections in hemodialysis patients: pathogenesis and prevention Kidney
Int 2005 Vol. 67 Issue 6 Pages 2508-19 Accession Number: 15882306 DOI: 10.1111/j.1523-
1755.2005.00364.x https://www.ncbi.nlm.nih.gov/pubmed/15882306

4. Vaziri ND, Pahl MV, Crum A and Norris K Effect of uremia on structure and function of immune system
J Ren Nutr 2012 Vol. 22 Issue 1 Pages 149-56 Accession Number: 22200433 PMCID: PMC3246616 DOI: 10.1053/j.jrn.2011.10.020
https://www.ncbi.nlm.nih.gov/pubmed/22200433

5. Flythe JE, Assimon MM, Tugman MJ, Chang EH, Gupta S, Shah J, Sosa MA, Renaghan AD, Melamed ML, Wilson FP, Neyra JA, Rashidi A, Boyle SM, Anand S, Christov M, Thomas LF, Edmonston D, Leaf DE; STOP-COVID Investigators. Characteristics and Outcomes of Individuals With Pre-existing Kidney Disease and COVID-19 Admitted to Intensive Care Units in the United States. Am J Kidney Dis. 2021 Feb;77(2):190-203.e1. doi: 10.1053/j.ajkd.2020.09.003. Epub 2020 Sep 19. PMID: 32961244; PMCID: PMC7501875.

6. Palevsky P, Radhakrishnan J, Townsend R Coronavirus disease 2019 (COVID-19): Issues related to kidney disease and hypertension
https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-issues-related-to-kidney-disease-and-hypertension

7. Fisher M, Yunes M, Mokrzycki M, Golestaneh L, Alahiri E, and Coco M Chronic Hemodialysis Patients Hospitalized with COVID-19: Short-term Outcomes in the Bronx, New York
Kidney360 August 2020, 1 (8) 755-762; DOI: https://doi.org/10.34067/KID.0003672020

8. Gasparini M, Khan S, Patel JM, Parekh D, Bangash MN, Stümpfle R, Shah A, Baharlo B, Soni S; Collaborators. Renal impairment and its impact on clinical outcomes in patients who are critically ill with COVID-19: a multicentre observational study. Anaesthesia. 2021 Mar;76(3):320-326. doi: 10.1111/anae.15293. Epub 2020 Oct 16. PMID: 33948938.

9. Ng JH, Hirsch JS, Wanchoo R, Sachdeva M, Sakhiya V, Hong S, Jhaveri KD, Fishbane S; Northwell COVID-19 Research Consortium and the Northwell Nephrology COVID-19 Research Consortium. Outcomes of patients with end-stage kidney disease hospitalized with COVID-19. Kidney Int. 2020 Dec;98(6):1530-1539. doi: 10.1016/j.kint.2020.07.030. Epub 2020 Aug 15. PMID: 32810523; PMCID: PMC7428720.

10. Naaraayan A, Nimkar A, Hasan A, Pant S, Durdevic M, Elenius H, Nava Suarez C, Basak P, Lakshmi K, Mandel M, Jesmajian S. End-Stage Renal Disease Patients on Chronic Hemodialysis Fare Better With COVID-19: A Retrospective Cohort Study From the New York Metropolitan Region. Cureus. 2020 Sep 11;12(9):e10373. doi: 10.7759/cureus.10373. PMID: 33062496; PMCID: PMC7550023.

11. Chan L, Jaladanki SK, Somani S, Paranjpe I, Kumar A, Zhao S, Kaufman L, Leisman S, Sharma S, He JC, Murphy B, Fayad ZA, Levin MA, Bottinger EP, Charney AW, Glicksberg BS, Coca SG, Nadkarni GN; Mount Sinai COVID Informatics Center (MSCIC). Outcomes of Patients on Maintenance Dialysis Hospitalized with COVID-19. Clin J Am Soc Nephrol. 2021 Mar 8;16(3):452-455. doi: 10.2215/CJN.12360720. Epub 2020 Oct 30. PMID: 33127607; PMCID: PMC8011022.

12. Khatri M, Charytan DM, Parnia S, Petrilli SM, Michael J, Liu D, Tatapudi V, Jones S, Benstein J and Horwitz LI Outcomes among Hospitalized Chronic Kidney Disease Patients with COVID-19 Kidney360 July 2021, 2 (7) 1107-1114; DOI: https://doi.org/10.34067/KID.0006852020.

13. Nile SH, Nile A, Qiu J, Li L, Jia X, Kai G. COVID-19: Pathogenesis, cytokine storm and therapeutic potential of interferons. Cytokine Growth Factor Rev. 2020 Jun;53:66-70. doi: 10.1016/j.cytogfr.2020.05.002. Epub 2020 May 7. PMID: 32418715; PMCID: PMC7204669.

14. University of Wisconsin School of Medicine Public Health. 2015 Area Deprivation Index v2.0. Downloaded from https://www.neighborhoodatlas.medicine.wisc.edu

15. Kind AJH, Buckingham WR. Making Neighborhood-Disadvantage Metrics Accessible - The Neighborhood Atlas. N Engl J Med. 2018 Jun 28;378(26):2456-2458. doi: 10.1056/NEJMp1802313. PMID: 29949490; PMCID: PMC6051533.

16. PASS 2019 Power analysis and sample size www.ncss.com

17. Hick, J. L., D. Hanfling, M. Wynia, and E. Toner. 2021. Crisis Standards of Care and COVID-19: What Did We Learn? How Do We Ensure Equity? What Should We Do? NAM Perspectives. Discussion, National Academy of Medicine, Washington, DC. https://doi.org/10.31478/202108e.

18. Cleveland Manchanda EC, Sanky C, Appel JM. Crisis Standards of Care in the USA: A Systematic Review and Implications for Equity Amidst COVID-19. J Racial Ethn Health Disparities. 2021;8(4):824-836. doi:10.1007/s40615-020-00840-5

19. Eskandar EN, Altschul DJ, de la Garza Ramos R, Cezayirli P, Unda SR, Benton J, Dardick J, Toma A, Patel N, Malaviya A, Flomenbaum D, Fernandez-Torres J, Lu J, Holland R, Burchi E, Zampolin R, Hsu K, McClelland A, Burns J, Erdfarb A, Malhotra R, Gong M, Semczuk P, Gursky J, Ferastraoaru V, Rosengard J, Antoniello D, Labovitz D, Esenwa C, Milstein M, Boro A, Mehler MF. Neurologic Syndromes Predict Higher In-Hospital Mortality in COVID-19. Neurology. 2021 Mar 16;96(11):e1527-e1538. doi: 10.1212/WNL.0000000000011356. Epub 2020 Dec 18. Erratum in: Neurology. 2021 Mar 16;96(11):551. PMID: 33443111; PMCID: PMC8032378.

20. The Monmouth University Poll, sponsored and conducted by the Monmouth University Polling Institute from February 25 to March 1, 2021 with a national random sample of 802 adults age 18 and older

21. Twohig KA, Nyberg T, Zaidi A, Thelwall S, Sinnathamby MA, Aliabadi S, Seaman SR, Harris RJ, Hope R, Lopez-Bernal J, Gallagher E, Charlett A, De Angelis D, Presanis AM, Dabrera G; COVID-19 Genomics UK (COG-UK) consortium. Hospital admission and emergency care attendance risk for SARS-CoV-2 delta (B.1.617.2) compared with alpha (B.1.1.7) variants of concern: a cohort

study. Lancet Infect Dis. 2021 Aug 27:S1473-3099(21)00475-8. doi: 10.1016/S1473-3099(21)00475-8. Epub ahead of print. PMID: 34461056; PMCID: PMC8397301.

Table 1.1 Demographic and clinical characteristics of patients with and without ESRD (N=5,761)

Variable		Non-ESRD n (%) (N=5,336)	ESRD n (%) (N=425)
Sex	Male	3018 (56.6)	243 (57.2)
Age (years)[1]		60 (45, 73)	61 (50, 71)
Age (%)	18-39	973 (18.2)	57 (13.4)
	40-49	675 (12.6)	47 (11.1)
	50-59	996 (18.7)	89 (20.9)
	60-69	1055 (19.8)	115 (27.1)
	70-79	819 (15.3)	69 (16.2)
	80+	818 (15.3)	48 (11.3)
Race/Ethnicity	White	1494 (28)	60 (14.1)
	Asian	582 (10.9)	39 (9.2)
	Other/Unknown	503 (9.4)	30 (7.1)
	Hispanic	2351 (44.1)	240 (56.5)
	Black	406 (7.6)	56 (13.2)
Area Deprivation Index[2]	Missing	870 (16.3)	33 (7.8)
	1	460 (8.6)	19 (4.5)
	2	414 (7.8)	28 (6.6)
	3	410 (7.7)	23 (5.4)
	4	529 (9.9)	40 (9.4)
	5	648 (12.1)	56 (13.2)
	6	531 (10)	60 (14.1)
	7	453 (8.5)	67 (15.8)
	8	362 (6.8)	34 (8)
	9	335 (6.3)	36 (8.5)
	10	324 (6.1)	29 (6.8)
Comorbid Conditions			
Cancer		957 (17.9)	64 (15.1)
Major Cardiac Disease		3271 (61.3)	404 (95.1)

Variable		Non-ESRD n (%) (N=5,336)	ESRD n (%) (N=425)
Valvular Cardiac Disease		1077 (20.2)	214 (50.4)
Cardiac Arrhythmias		3010 (56.4)	327 (76.9)
Peripheral Vascular Disease		628 (11.8)	163 (38.4)
Cerebrovascular		1009 (18.9)	147 (34.6)
Coagulopathy		1295 (24.3)	177 (41.6)
Anemia		816 (15.3)	165 (38.8)
Diabetes		2125 (39.8)	315 (74.1)
Drug Abuse		586 (11)	48 (11.3)
HIV/AIDS		76 (1.4)	7 (1.6)
Hypertension		3293 (61.7)	412 (96.9)
Hyperthyroidism		753 (14.1)	91 (21.4)
Liver Disease		1082 (20.3)	134 (31.5)
Chronic Neurological Conditions		1119 (21)	118 (27.8)
Acute Neurological Conditions		769 (14.4)	103 (24.2)
Obesity		1885 (35.3)	186 (43.8)
Paralysis		276 (5.2)	31 (7.3)
Chronic Psychoses		239 (4.5)	13 (3.1)
Acute Psychoses		64 (1.2)	3 (0.7)
Pulmonary Disease[3]		1897 (35.6)	205 (48.2)
Rheumatoid Arthritis/CVD		403 (7.6)	55 (12.9)
Smoking		1134 (21.3)	113 (26.6)
Solid Organ Transplantation, excluding Kidney		194 (3.6)	35 (8.2)

Abbreviations: CVD=Collagen Vascular Disease
[1]Data are expressed as medians (interquartile ranges)
[2]ADIs are calculated in deciles with an ADI of 1 and 10 signifying a neighborhood that is least and most socioeconomically disadvantaged, respectively
[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Table 1.2 Odds ratios for in-hospital death and hospital LOS of 7 days or longer among patients with ESRD (the group without ESRD is the referent)

Outcomes	OR	95% CI	p Value
In-hospital death (N=5,761)			
Unadjusted	1.48	1.09, 2.01	0.013
Adjusted model 1[1]	1.41	1.02, 1.94	0.035
Adjusted model 2[2]	0.86	0.61, 1.22	0.393
Hospital length of stay (<7 vs ≥ 7 days) (N=5,260)[3]			
Unadjusted	1.69	1.37, 2.09	p < 0.001
Adjusted model 1[1]	1.61	1.29, 1.99	p < 0.001
Adjusted model 2[4]	1.16	0.92, 1.46	0.202

Abbreviations: OR: odds ratio

[1]Adjusted model 1 adjusted for demographic variables sex, age category, and race/ethnicity

[2]Adjusted model 2 adjusted for demographic variables, acute neurological conditions, cardiac arrhythmias, cardiac valvular disease, major cardiac disease, cerebrovascular disease, coagulopathy, diabetes, and hypertension

[3]The analyses of hospital LOS were performed only among those patients who were discharged alive

[4]Adjusted model 2 adjusted for demographic variables, peripheral vascular disease, cardiac arrhythmias, major cardiac disease, diabetes, and hypertension

Table 1.3 Univariate and multivariate logistic regression analyses of risk factors associated with in-hospital death among all patients (N=5,761)

Variable		Univariate			Multivariate[1]		
		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
Age (per 10 years increase)		1.62	1.52, 1.72	<.0001	1.49	1.39, 1.61	<.0001
Sex	Female (referent)						
	Male	1.39	1.15, 1.69	0.0006	1.42	1.15, 1.74	0.0009
Race/Ethnicity	White (referent)						
	Asian	1.35	0.99, 1.84	0.0589	1.19	0.85, 1.68	0.3089
	Black	1.04	0.72, 1.5	0.8425	1.27	0.85, 1.9	0.2406
	Hispanic	1.03	0.82, 1.29	0.7877	2.08	1.61, 2.7	<.0001
	Other/ Unknown	0.89	0.61, 1.29	0.5310	1.23	0.83, 1.84	0.3059
Area Deprivation Index[2]	1	1.04	0.66, 1.66	0.8524			
	2	0.68	0.41, 1.14	0.1449			
	3	0.80	0.49, 1.32	0.3781			
	4	1.04	0.67, 1.63	0.8486			
	5	0.97	0.63, 1.5	0.8930			
	6	1.14	0.73, 1.77	0.5597			
	7	1.00	0.63, 1.58	0.9936			
	8	0.63	0.37, 1.08	0.0946			
	9	0.83	0.49, 1.38	0.4646			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		1.21	0.96, 1.52	0.1061			
Major Cardiac Disease		5.83	4.32, 7.87	<.0001	2.42	1.74, 3.36	<.0001

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Valvular Cardiac Disease		1.95	1.61, 2.38	<.0001			
Cardiac Arrhythmias		4.04	3.17, 5.14	<.0001	2.24	1.72, 2.91	<.0001
Peripheral Vascular Disease		1.36	1.07, 1.74	0.0136	0.74	0.56, 0.97	0.0279
Coagulopathy		2.35	1.95, 2.84	<.0001	1.61	1.3, 1.98	<.0001
Anemia		1.21	0.96, 1.52	0.1149	0.77	0.59, 0.99	0.0442
Diabetes		1.68	1.4, 2.02	<.0001			
HIV/AIDS		0.53	0.19, 1.45	0.2144			
Hypertension		2.85	2.24, 3.61	<.0001			
Hyperthyroidism		1.45	1.15, 1.83	0.0019			
Chronic Neurological Conditions		2.10	1.73, 2.56	<.0001	0.72	0.56, 0.91	0.0056
Obesity		0.83	0.68, 1.01	0.0630			
Paralysis		2.16	1.57, 2.97	<.0001			
Chronic Psychoses		0.75	0.46, 1.24	0.2633			
Acute Psychoses		0.32	0.08, 1.31	0.1139			
Pulmonary Disease[4]		1.85	1.54, 2.22	<.0001	1.25	1.02, 1.55	0.0340
Rheumatoid Arthritis/CVD		1.01	0.72, 1.41	0.9765			
Smoking		1.17	0.94, 1.45	0.1543			
Solid Organ Transplantation		0.84	0.51, 1.38	0.4861			
Liver Disease		1.36	1.1, 1.68	0.0039			

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Cerebrovascular Disease		2.03	1.66, 2.48	<.0001			
Drug Abuse		0.72	0.52, 1	0.0510			
Acute Neurological Conditions		6.87	5.66, 8.34	<.0001	4.34	3.49, 5.41	<.0001

Abbreviations: OR=odds ratio, CVD=collagen vascular disease

[1]The demographic variables age, sex, and race/ethnicity and factors significant at the p= 0.05 level in two-sided tests were included in the multivariate model

[2]ADIs are calculated in deciles from 1 to 10, with an ADI of 1 signifying a neighborhood that is least socioeconomically disadvantaged and an ADI of 10 signifying a neighborhood which is most socioeconomically disadvantaged

[3]For comorbid conditions the absence of the condition is the referent

[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Figure 1.1 Forest plot showing the multivariate risk factors for in-hospital death among all patients (N=5,761)
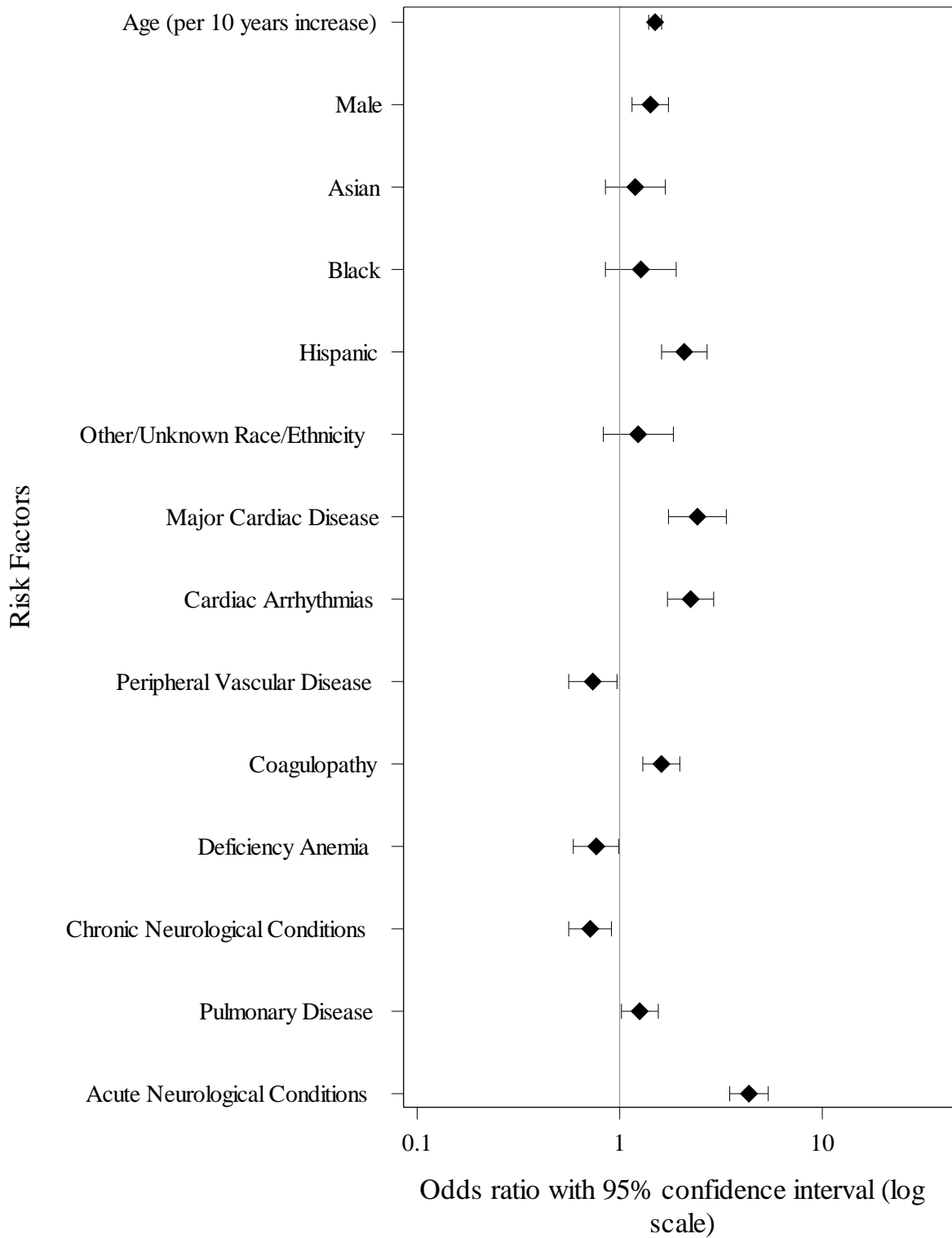

Odds ratio with 95% confidence interval (log scale)

Table 1.4 Univariate and multivariate logistic regression analyses of risk factors associated with hospital LOS of ≥7 days among patients who were discharged alive (N=5,260)

Variable		Univariate			Multivariate[1]		
		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
Age (per 10 years increase)		1.24	1.2, 1.28	<.0001	1.14	1.1, 1.18	<.0001
Sex	Female (referent)						
	Male	1.22	1.09, 1.36	0.0004	1.25	1.11, 1.41	0.0002
Race/Ethnicity	White (referent)						
	Asian	1.17	0.96, 1.43	0.1160	1.11	0.89, 1.37	0.3544
	Black	1.05	0.84, 1.31	0.6619	1.09	0.86, 1.37	0.4937
	Hispanic	0.96	0.84, 1.09	0.5306	1.28	1.1, 1.49	0.0014
	Other/Unknown	0.97	0.79, 1.19	0.7522	1.15	0.92, 1.43	0.2252
Area Deprivation Index[2]	1	1.13	0.85, 1.52	0.3976			
	2	1.05	0.78, 1.41	0.7431			
	3	0.83	0.62, 1.12	0.2218			
	4	0.94	0.71, 1.24	0.6543			
	5	0.84	0.64, 1.1	0.2118			
	6	0.81	0.61, 1.07	0.1452			
	7	1.02	0.76, 1.35	0.9138			
	8	0.93	0.69, 1.26	0.6454			
	9	1.21	0.89, 1.64	0.2259			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		1.15	1, 1.33	0.0514			
Major Cardiac Disease		2.41	2.14, 2.71	<.0001	1.65	1.43, 1.9	<.0001
Valvular Cardiac Disease		1.33	1.17, 1.52	<.0001	0.76	0.65, 0.89	0.0005
Cardiac Arrhythmias		1.89	1.69, 2.11	<.0001	1.33	1.17, 1.51	<.0001

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Peripheral Vascular Disease		1.61	1.37, 1.88	<.0001			
Coagulopathy		1.78	1.57, 2.02	<.0001	1.37	1.19, 1.58	<.0001
Anemia		1.53	1.32, 1.77	<.0001			
Diabetes		1.66	1.49, 1.86	<.0001	1.23	1.09, 1.4	0.0011
HIV/AIDS		0.83	0.52, 1.3	0.4129			
Hypertension		1.92	1.71, 2.15	<.0001			
Hyperthyroidism		1.33	1.14, 1.55	0.0004			
Chronic Neurological Conditions		1.96	1.71, 2.25	<.0001			
Obesity		1.15	1.02, 1.28	0.0186	1.18	1.04, 1.34	0.0109
Paralysis		2.02	1.56, 2.61	<.0001			
Chronic Psychoses		1.60	1.23, 2.08	0.0005			
Acute Psychoses		2.22	1.33, 3.68	0.0021	3.02	1.75, 5.22	<.0001
Pulmonary Disease[4]		1.49	1.33, 1.67	<.0001	1.17	1.03, 1.34	0.0159
Rheumatoid Arthritis/CVD		1.19	0.98, 1.46	0.0812			
Smoking		1.25	1.1, 1.43	0.0009			
Solid Organ Transplantation		0.93	0.7, 1.22	0.5911	0.67	0.5, 0.91	0.0093
Liver Disease		1.22	1.07, 1.4	0.0032			
Cerebrovascular Disease		1.65	1.44, 1.9	<.0001			
Drug Abuse		1.15	0.97, 1.36	0.1176			
Acute Neurological Conditions		5.02	4.14, 6.1	<.0001	3.58	2.92, 4.38	<.0001

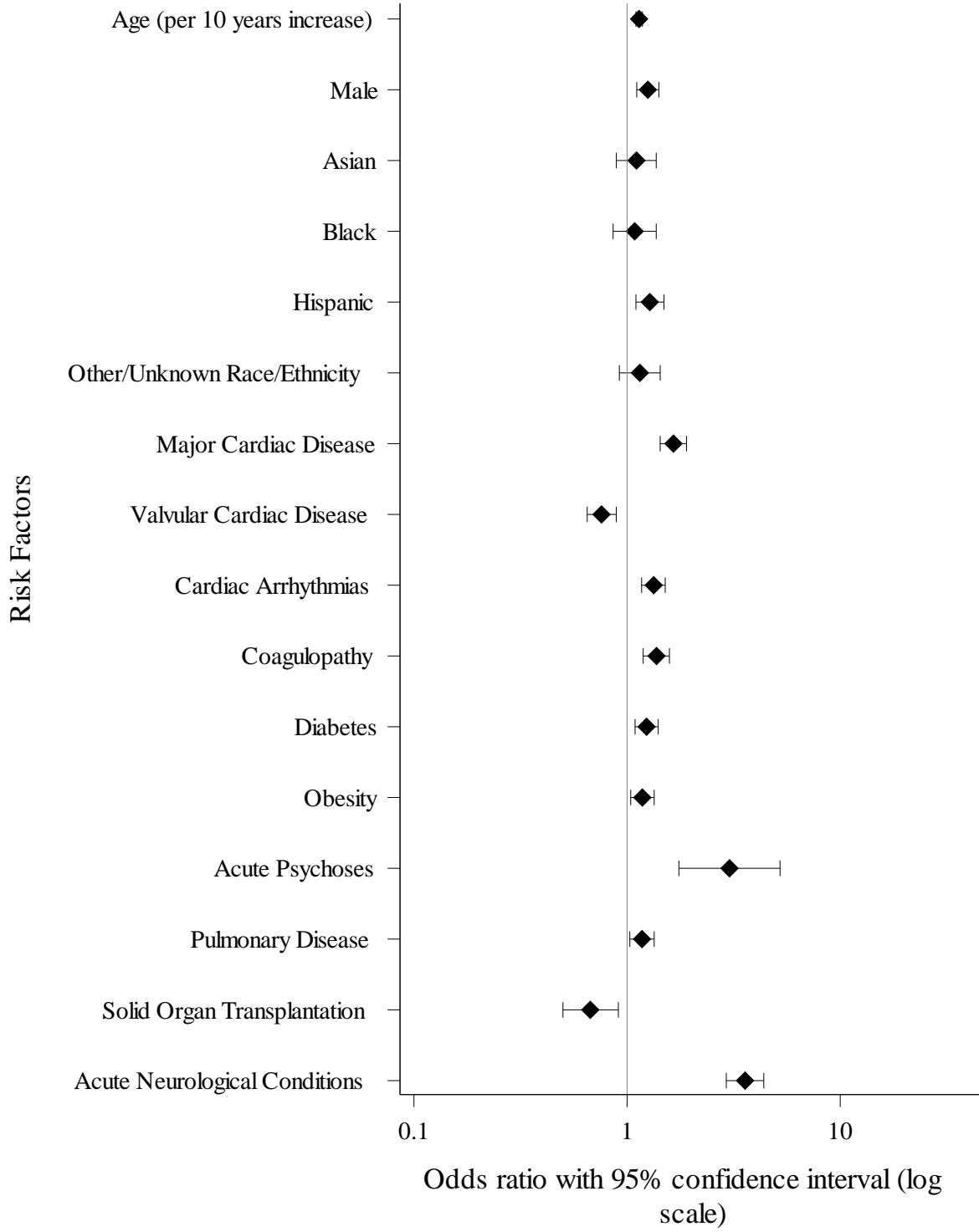Abbreviations: OR=odds ratio, CVD=collagen vascular disease
[1]The demographic variables age, sex, and race/ethnicity and factors significant at the p= 0.05 level in two-sided tests were included in the multivariate model
[2]ADIs are calculated in deciles from 1 to 10, with an ADI of 1 signifying a neighborhood that is least socioeconomically disadvantaged and an ADI of 10 signifying a neighborhood which is most socioeconomically disadvantaged
[3]For comorbid conditions the absence of the condition is the referent
[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Figure 1.2 Forest plot showing the multivariate risk factors for hospital LOS of 7 days or longer among patients who were discharged alive (N=5,260)

Odds ratio with 95% confidence interval (log scale)

Supplemental Appendix

Table of Contents

Supplemental Table S1.1 List of ICD-10-CM codes used to define COVID-19 positive test result, ESRD, and comorbid conditions included in study

Condition	ICD-10-CM Codes
COVID-19	Patients were considered to have a positive COVID-19 test result who were assigned one of the following logical observation identifiers names and codes (LOINC) codes: '94309-2', '94500-6', '94531-1', '94306-8', '94534-5', '94559-2', '94533-7', or '94310-0'.
End Stage Renal Disease (ESRD)	Patients were classified as having ESRD if their admission included the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients with an active renal transplant but did include patients with failed kidney transplants who were back on long-term dialysis, by simultaneously excluding subjects with ICD-10-CM codes T86.1, T86.10, T86.13, and T86.19, and Z94.0 (we did include those with failed kidney transplants by including those with an ICD-10-CM code T86.12).
Cancer	C00, C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C30, C31, C32, C33, C34, C37, C38, C39, C40, C41, C43, C45, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57, C58, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C88, C90.0, C90.2, C91.0, C91.1, C91.5, C92.0, C92.1, C92.4, C92.5, C92.6, C92.8, C96, C97
Major Cardiac Disease	A52.0 (Cardiovascular and cerebrovascular syphilis), I09.8 (Other specified rheumatic heart diseases), I09.9 (Rheumatic heart disease, unspecified), I25.10 (Atherosclerotic heart disease of native coronary artery without angina pectoris), I25.5 (Ischemic cardiomyopathy), I42.0 (Dilated cardiomyopathy), I42.5 (Other restrictive cardiomyopathy), I42.6 (Alcoholic cardiomyopathy), I42.7 (Cardiomyopathy due to drug and external agent), I42.8 (Other cardiomyopathies), I42.9 (Cardiomyopathy, unspecified), I43 (Cardiomyopathy in diseases classified elsewhere), I45.6 (Pre-excitation syndrome), I45.9 (Conduction disorder,

	unspecified), I50 (Heart failure), I70, (Atherosclerosis) I73.1 (Thromboangiitis obliterans [Buerger's disease]), I79.2, T82.1 (Mechanical complication of cardiac electronic device), Z45.0 (Encounter for adjustment and management of cardiac device), Z95.0 (Presence of cardiac pacemaker), Z95.8 (Presence of other cardiac and vascular implants and grafts), Z95.9 (Presence of cardiac and vascular implant and graft, unspecified)
Hypertension	I11.0 (Hypertensive heart disease with heart failure), I13.0 (Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease), I13.2 (Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease), I10 (Essential (primary) hypertension), I11 (Hypertensive heart disease), I12 (Hypertensive chronic kidney disease), I13 (Hypertensive heart and chronic kidney disease), I15 (Secondary hypertension)
Cardiac Valvular Disease	I05 (Rheumatic mitral valve diseases), I06 (Rheumatic aortic valve diseases), I07(Rheumatic tricuspid valve diseases), I08 (Multiple valve diseases), I09.1, (Rheumatic diseases of endocardium, valve unspecified), I34 (Nonrheumatic mitral valve disorders), I35 (Nonrheumatic aortic valve disorders), I36 (Nonrheumatic tricuspid valve disorders), I37 (Nonrheumatic pulmonary valve disorders), I38 (Endocarditis, valve unspecified), I39 (Endocarditis and heart valve disorders in diseases classified elsewhere), Q23.0 (Congenital stenosis of aortic valve), Q23.1, (Congenital insufficiency of aortic valve), Z95.2 (Presence of prosthetic heart valve), Z95.3 (Presence of xenogenic heart valve), Z95.4 (Presence of other heart-valve replacement), I71 (Aortic aneurysm and dissection), Q23.2 (Congenital mitral stenosis), Q23.3 (Congenital mitral insufficiency),
Cardiac Arrhythmias	I47 (Paroxysmal tachycardia), I48 (Atrial fibrillation and flutter), I49 (Other cardiac arrhythmias), I44.1 (Atrioventricular block, second degree), I44.2 (Atrioventricular block, complete), I44.3 (Other and unspecified atrioventricular block), R00.0 (Tachycardia,

	unspecified), R00.1 (Bradycardia, unspecified), R00.8 (Other abnormalities of heart beat),
Cardiac Peripheral Vascular Disease	I73.8 (Other specified peripheral vascular diseases), I73.9 (Peripheral vascular disease, unspecified), K55.1 (Chronic vascular disorders of intestine), K55.8 (Other vascular disorders of intestine), K55.9 (Vascular disorder of intestine, unspecified), I77.1 (Stricture of artery), I79.0 (Aneurysm of aorta in diseases classified elsewhere)
CerebrovascularDisease	G45 (Transient cerebral ischemic attacks and related syndromes), G46 (Vascular syndromes of brain in cerebrovascular diseases), H34.0 (Transient retinal artery occlusion), I60 (Nontraumatic subarachnoid hemorrhage), I61 (Nontraumatic intracerebral hemorrhage), I62 (Other and unspecified nontraumatic intracranial hemorrhage), I63 (Cerebral infarction), I64, I65 (Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction), I66 (Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction), I67 (Other cerebrovascular diseases), I68 (Cerebrovascular disorders in diseases classified elsewhere), I69 (Sequelae of cerebrovascular disease)
Coagulopathy	D65 (Disseminated intravascular coagulation [defibrination syndrome]), D66 (Hereditary factor VIII deficiency), D67 (Hereditary factor IX deficiency), D68 (Other coagulation defects), D69.1 (Qualitative platelet defects), D69.3 (Immune thrombocytopenic purpura), D69.4 (Other primary thrombocytopenia), D69.5 (Secondary thrombocytopenia), D69.6 (Thrombocytopenia, unspecified)
Anemia	D50.8 (Other iron deficiency anemias), D50.9 (Iron deficiency anemia, unspecified), D51 (Vitamin B12 deficiency anemia), D52 (Folate deficiency anemia), D53 (Other nutritional anemias)
Diabetes	E10.0, E10.1, E10.2, E10.3, E10.4, E10.5, E10.6, E10.7, E10.8, E10.9, E11.0, E11.1, E11.2, E11.3, E11.4, E11.5, E11.6, E11.7, E11.8, E11.9, E12.0, E12.1, E12.2, E12.3, E12.4, E12.5, E12.6, E12.7, E12.8, E12.9, E13.0, E13.1, E13.2, E13.3, E13.4, E13.5, E13.6, E13.7, E13.8, E13.9, E14.0, E14.1, E14.2, E14.3, E14.4, E14.5, E14.6, E14.7, E14.8, E14.9

Drug Abuse	F11, F12, F13, F14, F15, F16, F18, F19, Z71.5, Z72.2
HIV/AIDS	B20 (Human immunodeficiency virus [HIV] disease)
Hypothyroidism	E00 (Congenital iodine-deficiency syndrome), E01 (Iodine-deficiency related thyroid disorders and allied conditions), E02 (Subclinical iodine-deficiency hypothyroidism), E03 (Other hypothyroidism), E89.0 (Postprocedural hypothyroidism)
Liver Disease	B18, I85, I86.4, I98.2, K70, K71.1, K71.3, K71.4, K71.5, K71.7, K72, K73, K74, K76.0, K76.2, K76.3, K76.4, K76.5, K76.6, K76.7, K76.8, K76.9, Z94.4
Chronic Neurological Conditions	F01.5 (Vascular dementia), F03.9 (Unspecified dementia), G10 (Huntingtons disease), G11 (hereditary ataxia), G12 (spinal muscular atrophy and related syndromes), G13 (systemic atrophies primarily affecting central nervous system in diseases classified elsewhere), G20 (Parkinsons disease), G21 (Secondary parkinsonism), G22, G25.4 (Drug-induced chorea), G25.5 (other chorea), G30 (Alzheimers disease), G31.2 (degeneration of nervous system due to alcohol), G31.8 (other specified degenerative diseases of nervous system), G31.9 (Degenerative disease of nervous system, unspecified), G32 (other degenerative disorders of nervous system in diseases classified elsewhere), G35 (Multiple Sclerosis), G36 (Other acute disseminated demyelination), G37 (Other demyelinating diseases of central nervous system), G40 (Epilepsy and recurrent seizures), G41, R47.0 (Dysphasia and aphasia), R56 (Convulsions, not elsewhere classified)
Acute Neurological Conditions (captured on day of index hospital admission only)	G93.1 (Anoxic brain damage, not elsewhere classified), G93.4 (other and unspecified encephalopathy)
Obesity	E66, Z68.3, Z68.4, E66.01, E66.2, Z68.4
Paralysis	G04.1 (Tropical spastic paraplegia), G11.4 (Hereditary spastic paraplegia), G80.1 (Spastic diplegic cerebral palsy), G80.2 (Spastic hemiplegic cerebral palsy), G81 (Hemiplegia and hemiparesis), G82 (Paraplegia (paraparesis) and quadriplegia (quadriparesis)), G83.0 (Diplegia of upper limbs), G83.1 (Monoplegia of lower limb), G83.2 (Monoplegia of upper limb), G83.3

	(Monoplegia, unspecified), G83.4 (Cauda equina syndrome), G83.9 (Paralytic syndrome, unspecified)
Chronic Psychoses	F20 (Schizophrenia), F22(Delusional disorders), F23 (Brief psychotic disorder), F24 (Shared psychotic disorder), F25 (Schizoaffective disorders), F28 (Other psychotic disorder not due to a substance or known physiological condition), F30.2 (Manic episode, severe with psychotic symptoms), F31.2 (Bipolar disorder, current episode manic severe with psychotic features), F31.5 (Bipolar disorder, current episode depressed, severe, with psychotic features)
Acute Psychoses (captured on day of index hospital admission only)	F29 (Unspecified psychosis not due to a substance or known physiological condition)
Pulmonary Disease[1]	E84.0, E84.11, E84.19, E84.9, I26, I27, I27.8, I27.9, I28.0, I28.8, I28.9, J40, J41, J42, J43, J44, J45, J45.4, J45.5, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67, J68.4, J70.1, J70.3, J84.1, J84.9
Rheumatoid Arthritis, Collagen Vascular Disease	L94.0, L94.1, L94.3, M05, M06, M08, M12.0, M12.3, M30, M31.0, M31.1, M31.2, M31.3, M32, M33, M34, M35, M45, M46.1, M46.8, M46.9
Smoking	F17, I73.1, J41, J42, J43, J44, T65.2, Z71.6, Z72.0
Solid Organ Transplantation, excluding kidney	Z94.1 (Heart transplant status), Z94.2 (Lung transplant status), Z94.3 (Heart and lungs transplant status), Z94.4 (Liver transplant status), Z94.83 (Pancreas transplant status)

[1]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S1.2 In-hospital medications and high acuity treatments administered to patients with and without ESRD (N=5,761)

Medication or Treatment		Non ESRD (N=5,336)	ESRD (N=425)
Remdesivir		1485 (27.8)	92 (21.6)
Dexamethasone		2900 (54.3)	207 (48.7)
Oral Blood Thinner		761 (14.3)	82 (19.3)
Monoclonal Antibodies		73 (1.4)	11 (2.6)
Bamlanivimab		25 (0.5)	6 (1.4)
Casirivimab		9 (0.2)	2 (0.5)
Tocilizumab		39 (0.7)	3 (0.7)
SSRIs		87 (1.6)	11 (2.6)
Fluoxetine		23 (0.4)	3 (0.7)
Fluvoxamine		1 (0.02)	0 (0.0)
Citalopram		35 (0.6)	5 (1.2)
Sertraline		26 (0.5)	3 (0.7)
Paroxetine		1 (0.02)	0 (0.0)
Escitalopram		31 (0.6)	4 (0.9)
Vortioxetine		3 (0.1)	0 (0.0)
Mechanical Ventilation		1204 (22.6)	115 (27.1)
ECMO		24 (0.4)	2 (0.5)
ICU Admission		1241 (23.3)	121 (28.5)

Abbreviations: ICU=Intensive Care Unit, ECMO=extracorporeal membrane oxygenation, SSRIs= Selective Serotonin Reuptake Inhibitors

Supplemental Table S1.3 Demographic and clinical characteristics of patients by alive or expired status (excluding still admitted patients) (N=5,761)

Variable		Discharged Alive n (%) (N=5,260)	Expired n (%) (N=501)
Sex	Male	2941 (55.9)	320 (63.9)
Age (years)[1]		58 (44, 71)	73 (62, 82)
Age (%)	18-39	1014 (19.3)	16 (3.2)
	40-49	697 (13.3)	25 (5)
	50-59	1030 (19.6)	55 (11)
	60-69	1056 (20.1)	114 (22.8)
	70-79	758 (14.4)	130 (25.9)
	80+	705 (13.4)	161 (32.1)
Race/Ethnicity	White	1424 (27.1)	130 (25.9)
	Asian	553 (10.5)	68 (13.6)
	Other/Unknown	493 (9.4)	40 (8)
	Hispanic	2368 (45)	223 (44.5)
	Black	422 (8)	40 (8)
Area Deprivation Index[2]	Missing	840 (16)	63 (12.6)
	1	431 (8.2)	48 (9.6)
	2	412 (7.8)	30 (6)
	3	399 (7.6)	34 (6.8)
	4	512 (9.7)	57 (11.4)
	5	638 (12.1)	66 (13.2)
	6	527 (10)	64 (12.8)
	7	470 (8.9)	50 (10)
	8	371 (7.1)	25 (5)
	9	341 (6.5)	30 (6)
	10	319 (6.1)	34 (6.8)
Comorbid Condition			
Cancer		919 (17.5)	102 (20.4)

Variable		Discharged Alive n (%) (N=5,260)	Expired n (%) (N=501)
Major Cardiac Disease		3223 (61.3)	452 (90.2)
Valvular Cardiac Disease		1118 (21.3)	173 (34.5)
Cardiac Arrhythmias		2919 (55.5)	418 (83.4)
Peripheral Vascular Disease		704 (13.4)	87 (17.4)
Cerebrovascular		995 (18.9)	161 (32.1)
Coagulopathy		1259 (23.9)	213 (42.5)
Anemia		883 (16.8)	98 (19.6)
Diabetes		2169 (41.2)	271 (54.1)
Drug Abuse		592 (11.3)	42 (8.4)
HIV/AIDS		79 (1.5)	4 (0.8)
Hypertension		3291 (62.6)	414 (82.6)
Hyperthyroidism		747 (14.2)	97 (19.4)
Liver Disease		1085 (20.6)	131 (26.1)
Chronic Neurological Conditions		1063 (20.2)	174 (34.7)
Acute Neurological Conditions		630 (12)	242 (48.3)
Obesity		1910 (36.3)	161 (32.1)
Paralysis		257 (4.9)	50 (10)
Chronic Psychoses		235 (4.5)	17 (3.4)
Acute Psychoses		65 (1.2)	2 (0.4)
Pulmonary Disease[3]		1851 (35.2)	251 (50.1)
Rheum Arthritis/CVD		418 (7.9)	40 (8)
Smoking		1126 (21.4)	121 (24.2)
Solid Organ Transplantation, excluding Kidney		212 (4)	17 (3.4)
ESRD		374 (7.1)	51 (10.2)
Remdesivir		1373 (26.1)	204 (40.7)
Dexamethasone		2700 (51.3)	407 (81.2)
Oral Blood Thinner		778 (14.8)	65 (13)

Variable		Discharged Alive n (%) (N=5,260)	Expired n (%) (N=501)
Monoclonal Antibodies		76 (1.4)	8 (1.6)
Bamlanivimab		30 (0.6)	1 (0.2)
Tocilizumab		35 (0.7)	7 (1.4)
Mechanical Ventilation		1157 (22)	162 (32.3)
ECMO		11 (0.2)	15 (3)
ICU Admission		1021 (19.4)	341 (68.1)

Abbreviations: ICU=intensive care unit, CVD=Collagen Vascular Disease, ECMO-extracorporeal membrane oxygenation

[1]Data are expressed as medians (interquartile ranges)

[2]ADIs are calculated in deciles from 1 to 10, with an ADI of 1 signifying a neighborhood that is least socioeconomically disadvantaged and an ADI of 10 signifying a neighborhood which is most socioeconomically disadvantaged

[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Chapter 2 Risks of ICU admission and ICU length of stay of 7 days or longer for end-stage renal disease patients hospitalized with COVID-19. A retrospective cohort study in 5 California medical centers.

Introduction

Since December 2019, infection with SARS-CoV-2, the virus which causes COVID-19, has led to the most serious infectious disease pandemic since the influenza pandemic of 1918-1920. In the United States, over 45.6 million cases of COVID-19 were diagnosed from February 2020 to October27, 2021, resulting in 739,259 deaths. In the state of California, over 4.8 million cases of COVID-19 were diagnosed in the same period, resulting in 71,800 deaths and 4,038 patients presently hospitalized (1). While the majority of individuals affected by COVID-19 exhibit only mild symptoms that do not require hospitalization, many require hospitalization, with the most ill patients needing intensive care unit (ICU) admission, mechanical ventilation and extracorporeal membrane oxygenation (ECMO) treatment.

Infection is the second most reported cause of death in the ESRD population 92). Annual death rates from pneumonia and sepsis are substantially higher among ESRD patients than among the general population (3). Patients with ESRD have a compromised and poorly regulated immune system which may increase susceptibility to bacterial and viral infections, including the SARS-COV-2 virus (4).

Some studies have found that individuals with chronic kidney disease and ESRD have a higher risk of serious outcomes from COVID-19, including a higher risk of ICU admission. Kipourou *et al* (5), in a retrospective study of 3,995 patients admitted with COVID-19 at Jaber Al-Ahmad Al-Sabah Hospital in Kuwait between February 24 and May 27, 2020, found chronic kidney disease, excluding dialysis, increased the risk of ICU admission within 10 days of hospital admission.

Other studies have found no increased risk for ICU admission, and even decreased risk from

COVID-19 in ESRD patients (6, 7, 8).   Investigators of these studies have suggested that the

diminished immune system response to SARS-CoV-2 of patients with ESRD may limit the

cytokine storm and systemic inflammation that can result when patients first encounter the

virus (9). Pathophysiologically, the systemic inflammatory response to the virus, and not the

virus itself, appears to contribute to much of the acute and chronic clinical manifestations of

COVID-19. In their study of patients admitted with COVID-19 to the Mount Sinai Health Care

System between March 15 and June 7, 2020, Chan *et al* (7) found a significantly lower odds of

ICU admission among patients with kidney failure versus propensity matched patients without

kidney failure (adjusted OR 0.37, 95% CI 0.19-0.71), but suggested that patients in their study

may have received different clinical treatments than patients hospitalized later in the

pandemic. Naaraayan *et al* (6), in their study of patients admitted with COVID-19 at a teaching

hospital in the New York City metropolitan area between March 12 and May 13, 2020, found no

significant difference (adjusted OR 0.4, 95% CI 0.2-1.05) for the combined outcome of acute

respiratory distress syndrome or ICU admission among patients with and without ESRD.

We aimed to further examine the clinical outcomes of ESRD patients admitted for COVID-19 in

a diverse Western United States population. We sought to compare ICU admission and ICU LOS

≥7 days in ESRD patients to that of non-ESRD patients, in individuals admitted for COVID-19 to

any of 5 tertiary care University of California academic hospitals.

Materials and Methods

We used the University of California COVID Research Database (UC CORDS) which is a large,

harmonized database provided by the UC Health Data Warehouse (UCHDW) that includes

patients from the 5 tertiary care, academic hospitals of the University of California (UC Davis,

UC Irvine, UC Los Angeles, UC San Diego and UC San Francisco). The primary outcome was ICU

admission, and the secondary outcome was ICU LOS of ≥7 days. This retrospective study

included adult patients (≥18 years at time of hospital admission) with and without ESRD, and

who tested positive for COVID-19 by polymerase chain reaction nasal swab within 30 days prior

to or at any time during their hospital stay at any of the 5 University of California medical

centers. We included patients admitted between February 12, 2020 and September 6, 2021,

who were discharged alive or who died by September 7, 2021, the study end date. Patients

were classified as having ESRD if their admission included the International Classification of

Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients

with an active renal transplant from the ESRD group but included patients with failed kidney

transplants who were back on long-term dialysis. See **supplemental Table S2.1** for further

details.

For patients with multiple hospital admissions, only their index hospitalization associated with a

positive test for COVID-19 was included in the study. Individuals were excluded from the study

if they were transferred in from a hospital outside the University of California hospital system

(N=556), transferred out of the University of California hospital system (N=136), admitted to an

inpatient obstetric service (N=146), or were still receiving in-hospital care at the study end date.

43

Demographic and baseline characteristics included age at hospital admission in years, sex, race and ethnicity. Age was categorized as 18-39 (the referent), 40-49, 50-59, 60-69, 70-79 and 80+ years. Self-reported data on race and ethnicity were combined and categorized as White (White, non-Hispanic, the referent), Hispanic (White, Hispanic), Black, Asian, and Other/Unknown. In gender analyses, female was the referent.

Comorbid conditions identified in patients prior to or on their date of index hospital admission included: collagen vascular disease, immune system disease, including lupus, scleroderma and rheumatoid arthritis, hypothyroidism, drug use disorders, anemia, cerebrovascular disease, diabetes, hypertension, obesity, cardiac valvular disease, cardiac arrhythmias, cardiac peripheral vascular disease, major cardiac disease, HIV/AIDS, liver disease, paralysis cancer, chronic psychoses, chronic neurological conditions, pulmonary disease, solid organ transplantation (excluding kidney transplants) and smoking status (smoker/ever-smoker vs never smoker). If encephalopathy, acute psychosis was diagnosed on the day of index hospital admission, we considered these to be an acute neurological condition, acute psychosis, respectively. We grouped asthma and chronic obstructive pulmonary disease (COPD) into a single pulmonary disease factor. Patients were classified as having or not having these comorbid conditions using the ICD-10-CM codes listed in **supplemental Table S2.1**. For each comorbid condition, the absence of the condition was the referent.

Given the socioeconomic diversity of California, we also included the area deprivation index

(ADI) as a factor in our analyses. The ADI for a given neighborhood (census block group) is a

measure of relative socioeconomic disadvantage (10, 11) and is calculated by comparing

income, education, employment, and housing for that neighborhood against the mean values

of these factors for the given state (ADIs are state specific). ADIs are calculated in deciles with

an ADI of one signifying a neighborhood least socioeconomically disadvantaged and an ADI of

ten signifying a neighborhood which is most socioeconomically disadvantaged. Individuals in

the UC CORDS database were assigned an ADI based upon their residence zip code. In our

study, 7.8% of the ESRD patients and 16.3% of the non-ESRD patients, were missing an ADI,

which caused a reduction in the sample size available for our initial analyses when ADI was

considered as a factor.

Medications administered most likely for COVID-19 treatment during the hospital stay were

queried, including dexamethasone, remdesivir, oral anticoagulants and monoclonal antibodies

against SARS-CoV-2. Information was also collected on the use of mechanical ventilation and

extracorporeal membrane oxygenation (ECMO) treatment as indicators of disease severity.

The primary and secondary outcomes were ICU admission and ICU LOS of ≥7 days, respectively.

We utilized simple and multiple logistic regression analyses. The analyses of ICU LOS were

performed only among those patients discharged alive from the hospital. ICU LOS was

calculated as the total number of overnight stays in any ICU or CCU during the hospitalization,

with patients not admitted to any ICU or CCU assigned an ICU LOS of 0 days.

In addition to unadjusted models, two adjusted logistic regression models for ICU admission and ICU LOS of ≥7 days were analyzed. Model 1 included the demographic variables sex, age category, and race/ethnicity. Model 2 included the demographic variables plus any comorbid conditions (confounders) which were associated at the $p = 0.15$ level with both the outcome and the study exposure, and which caused a ≥ 10% change in the unadjusted exposure/outcome odds ratio when added as a factor to the unadjusted logistic regression model.

Backward logistic regression models were utilized to determine independent risk factors associated with ICU admission and ICU LOS of ≥7 days among patients with and without ESRD. Risk factors for the demographic variables sex, age (per 10 years increase), race/ethnicity, and comorbid conditions with odds ratios significant at the $p = 0.05$ level in two-sided tests were retained in each of the multivariate models.

Sample size calculations for the primary endpoint of the study, ICU admission, were performed as follows: A logistic regression of the outcome ICU admission on the study exposure, presence/absence of ESRD with a sample size of 4,523 observations (of which 6% have ESRD) achieves 80% power at a 0.05 significance level to detect a change in the probability of ICU admission from the baseline value of 0.240 to 0.321. This change corresponds to an odds ratio of 1.5. An adjustment was made since a multiple regression of the study exposure on the other independent variables in the logistic regression obtained an R-Squared of 0.1 (12).

This study was granted an exemption for human subject's protection by the UC Davis IRB Board (protocol# 1604619-1).

Results

After applying the study inclusion and exclusion criteria, a total of 5,761 patients were admitted to the hospital between February 12, 2020 to September 6, 2021 with a diagnosis of COVID-19 either within 30 days prior to or during their index hospitalization and were discharged alive or died during the study period. Of the 5,761 patients, 425 (7.4%) had ESRD and 5,336 (92.6%) did not have ESRD. In total, 5,260 patients (91.3%) were discharged alive and 501 (8.7%) died. In total, 1,362 patients (23.6%) were admitted to an ICU during their hospital stay and 4,399 (76.4%) were not; while for the two subgroups 121 (28.5%) were admitted to the ICU in the ESRD group, and 1,241 (23.3%) patients were admitted to an ICU in the non-ESRD group.

The demographic and clinical characteristics for patients with and without ESRD prior to hospital admission are provided in **Table 2.1**. Patients with ESRD were more likely than those without to live in a more socioeconomically disadvantaged census tract, to self-identify as either Hispanic (56.5% vs 44.1%) or Black (13.2% vs 7.6%), to be smokers (26.6% vs 21.3%), to be obese (43.8% vs 35.3%), and to have more major comorbid conditions. The in-hospital medications and high acuity treatments administered for COVID-19 in patients by study exposure group are provided in **supplemental Table S2.2.** The baseline characteristics of patients and the medications and treatments administered to patients while hospitalized,

among those admitted and not admitted to the ICU, are provided in **supplementary Table S2.5**.

Patients admitted to the ICU due to COVID-19 were older (median age 63 vs 59), more likely to

be male (62.1% vs 54.9%) and to self-identify as Hispanic (47.9% to 44.1%).

Unadjusted and multivariable-adjusted odds ratios for ICU admission and ICU LOS of ≥7 days

among patients with and without ESRD are provided in **Table 2.2**. After determining the factors

to be included in our adjusted model 2 analyses, we found that compared to patients without

kidney failure, patients with ESRD had a significantly higher odds of ICU admission in the

unadjusted analysis, but significantly lower odds in the analysis adjusted for demographic

variables and comorbid conditions (adjusted OR 0.75, 95% CI 0.59, 0.96, p=0.023). The odds of

ICU LOS of 7 days or longer was also significantly lower for those with ESRD in the adjusted

analysis (adjusted OR 0.55, 95% CI 0.37, 0.82, p=0.003).

The analyses of risk factors for ICU admission among patients without ESRD and with ESRD are

shown in **Table 2.3** and **Table 2.4**, respectively, and in **Figure 2.1**, while the analyses of risk

factors for ICU LOS of ≥7 days among patients without ESRD and with ESRD are shown in

supplemental Table S2.3 and **supplemental Table S2.4**, respectively, and in **supplemental

Figure S2.1**.

Discussion

Using a large database that spans the 5 academic medical centers of the University of

California, we sought to determine if ESRD was independently associated with a higher risk for

ICU admission and ICU length of stay of ≥7 days for patients diagnosed with COVID-19 with

ESRD versus patients without. While we identified patient demographic and health factors that

were independently linked to higher risks of these 2 important outcomes, we found that ESRD

status in contrast, was independently associated with lower risks of these outcomes.

Our findings agreed with that of other studies in which ESRD status was determined to not be

significantly associated with the risk of ICU admission related to COVID-19 or to be

independently associated with a lower risk of this outcome (6, 7, 8). The results of our study

differ however, with a large study of COVID-19 hospitalizations at Jaber Al-Ahmad Al-Sabah

Hospital in Kuwait by Kipourou *et al* (5), in which the hazard of ICU admission was significantly

higher for patients with chronic kidney disease not receiving dialysis, compared to patients

without this disease (hazard ratio 1.85 95% CI 1.16, 2.97). The contrasting conclusions of these

two studies may be due to the difference between the chronic kidney disease and ESRD disease

processes, selection of factors into the multivariate logistic regression models, or differences in

the patient populations.

In our study, we identified other factors that were independently associated with higher risk for

ICU admission and longer ICU stay. One of these factors was diagnosis of an acute neurological

decline, such as acute encephalopathy, at the time of hospital admission. In other studies,

neurological conditions have been found to be associated with a poor outcome among patients

hospitalized with COVID-19. In a cohort study of 3,744 patients hospitalized for COVID-19 at 28

medical centers in 13 countries, Chou *et al* (13) identified acute encephalopathy in 49% of the

patients and found that presence of neurologic symptoms was significantly associated with increased risk of in-hospital death (adjusted odds ratio, 5.99; 95% CI, 4.33-8.28). Eskandar *et al* (14) also found altered mentation and acute stroke on admission to be significantly associated with higher risk of in-hospital mortality, independent of other comorbid conditions.

In contrast, we found tobacco use to be linked with lower risk for ICU admission and longer ICU stay. Other studies have found smoking to be associated with lower risk of serious outcomes from COVID-19. Williamson *et al* (15) concluded that current smokers had a significantly lower hazard of death from COVID-19, but suggested that other factors in their model, such as respiratory disease, were likely mediators of the association between smoking and death from COVID-19. Paleiron *et al* (16) found that smokers had a significantly lower odds of acquiring COVID-19 and suggested that this effect might be due to nicotine, by competing with the SARS-Cov2 virus for binding to nAchR receptors in the respiratory tract. Other studies have found smoking to be linked with higher risk of serious outcomes from COVID-19 (17, 18). In a systematic review and meta-analysis of 46 peer-reviewed papers that studied a total of 22,939 COVID-19 patients, Patanavanich *et al* (17), found associations between having ever smoked and COVID-19 progression (OR 1.59, 95% CI 1.33–1.89, *p* = 0.001), particularly among adults under age 45, and increased risk of death from COVID-19 (OR 1.19, 95% CI 1.02–1.39, p = 0.003).

Other factors were associated with qualitatively different risks of ICU admission for ESRD and non-ESRD patients. These included black race, which was associated with higher, lower risk of

ICU admission for ESRD, non-ESRD patients, respectively, and diabetes and paralysis, which were associated with lower, higher risk of ICU admission for ESRD, non-ESRD patients, respectively.

The strengths of this study include its large cohort size and the extensive geographical and population range covered by the 5 academic medical centers. We likewise included an extensive number of comorbid conditions, including acute neurological conditions and coagulopathy, and we were able to capture the key therapeutics used to treat COVID-19 patients.

Like all studies of this kind, the retrospective nature is a limitation. An additional limitation includes comorbidity ascertainment by diagnostic codes, which vary in their degree of accuracy and completeness, and which we were not able to validate with chart review due to the pseudonymized nature of the dataset. Also, this study spans many months through the pandemic, and patient care management with increased experience with COVID-19 care may have changed clinical practices over time, possibly resulting in aggregation bias. The wider availability and use of COVID-19 vaccines over the study period could also conceivably have contributed to aggregation bias. Given the nature of the UC CORDS database, it was also not possible to study some key patient-level variables, including COVID-19 symptoms, blood type, vaccination status, as well as personal health habits such as masking, hand washing and social distancing practices, all which might have affected ICU outcomes for hospitalized patients.

The widespread presence of the delta variant of SARS-COV-2 in the United States has led to higher rates of hospital and ICU admission among those with Covid-19. Twohig et al (19) found that the hazard of hospitalization among those with the delta variant of SARS-COV-2 was significantly higher than among those with the alpha variant of this virus (hazard ratio 2.26, CI 1.32-3.89), while Fisman *et al* (20) found a significantly higher odds of ICU admission and mortality among those with the delta variant of SARS-COV-2 than among those without this variant (adj OR 3.87 95% CI 2.98-4.99) (18). It therefore appears likely that Covid-19, like influenza, will become an endemic disease in the US, and that many individuals, including those with ESRD, will continue to require hospitalization and ICU care as a result.

Patients with ESRD have many of the comorbid conditions linked with a worse outcome from COVID-19 hospitalization. Possibly due to the immune system compromise of these patients, and the resulting reduction of cytokine storms and systemic inflammation, we found upon adjusting for demographic variables and comorbid conditions that presence of ESRD was independently associated with lower risks for ICU admission and ICU LOS ≥7 days.

References
1. New York Times COVID-19 statistics
https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html

2. Harris, Randall E. Epidemiology of Chronic Disease pages 471-488

3. Jaber BL Bacterial infections in hemodialysis patients: pathogenesis and prevention Kidney Int 2005 Vol. 67 Issue 6 Pages 2508-19 Accession Number: 15882306 DOI: 10.1111/j.1523-1755.2005.00364.x
https://www.ncbi.nlm.nih.gov/pubmed/15882306

4. Vaziri ND, Pahl MV, Crum A and Norris K Effect of uremia on structure and function of immune system J Ren Nutr 2012 Vol. 22 Issue 1 Pages 149-56 Accession Number: 22200433 PMCID: PMC3246616 DOI: 10.1053/j.jrn.2011.10.020 https://www.ncbi.nlm.nih.gov/pubmed/22200433

5. Kipourou, DK., Leyrat, C., Alsheridah, N. *et al.* Probabilities of ICU admission and hospital discharge according to patient characteristics in the designated COVID-19 hospital of Kuwait. *BMC Public Health* **21,** 799 (2021). https://doi.org/10.1186/s12889-021-10759-z

6. Naaraayan A, Nimkar A, Hasan A, Pant S, Durdevic M, Elenius H, Nava Suarez C, Basak P, Lakshmi K, Mandel M, Jesmajian S. End-Stage Renal Disease Patients on Chronic Hemodialysis Fare Better With COVID-19: A Retrospective Cohort Study From the New York Metropolitan Region. Cureus. 2020 Sep 11;12(9):e10373. doi: 10.7759/cureus.10373. PMID: 33062496; PMCID: PMC7550023.

7. Chan L, Jaladanki SK, Somani S, Paranjpe I, Kumar A, Zhao S, Kaufman L, Leisman S, Sharma S, He JC, Murphy B, Fayad ZA, Levin MA, Bottinger EP, Charney AW, Glicksberg BS, Coca SG, Nadkarni GN; Mount Sinai COVID Informatics Center (MSCIC). Outcomes of Patients on Maintenance Dialysis Hospitalized with COVID-19. Clin J Am Soc Nephrol. 2021 Mar 8;16(3):452-455. doi: 10.2215/CJN.12360720. Epub 2020 Oct 30. PMID: 33127607; PMCID: PMC8011022.

8. Khatri M, Charytan DM, Parnia S, Petrilli SM, Michael J, Liu D, Tatapudi V, Jones S, Benstein J and Horwitz LI Outcomes among Hospitalized Chronic Kidney Disease Patients with COVID-19 Kidney360 July 2021, 2 (7) 1107-1114; DOI: https://doi.org/10.34067/KID.0006852020.

9. Nile SH, Nile A, Qiu J, Li L, Jia X, Kai G. COVID-19: Pathogenesis, cytokine storm and therapeutic potential of interferons. Cytokine Growth Factor Rev. 2020 Jun;53:66-70. doi: 10.1016/j.cytogfr.2020.05.002. Epub 2020 May 7. PMID: 32418715; PMCID: PMC7204669.

10. University of Wisconsin School of Medicine Public Health. 2015 Area Deprivation Index v2.0. Downloaded from https://www.neighborhoodatlas.medicine.wisc.edu

11. Kind AJH, Buckingham WR. Making Neighborhood-Disadvantage Metrics Accessible - The Neighborhood Atlas. N Engl J Med. 2018 Jun 28;378(26):2456-2458. doi: 10.1056/NEJMp1802313. PMID: 29949490; PMCID: PMC6051533.

12. PASS 2019 Power analysis and sample size www.ncss.com

13. Chou SH, Beghi E, Helbok R, *et al.* Global Incidence of Neurological Manifestations Among Patients Hospitalized With COVID-19—A Report for the GCS-NeuroCOVID Consortium and the ENERGY Consortium. *JAMA Netw Open.* 2021;4(5):e2112131. doi:10.1001/jamanetworkopen.2021.12131

14. Eskandar EN, Altschul DJ, de la Garza Ramos R, Cezayirli P, Unda SR, Benton J, Dardick J, Toma A, Patel N, Malaviya A, Flomenbaum D, Fernandez-Torres J, Lu J, Holland R, Burchi E, Zampolin R, Hsu K, McClelland A, Burns J, Erdfarb A, Malhotra R, Gong M, Semczuk P, Gursky J, Ferastraoaru V, Rosengard J, Antoniello D, Labovitz D, Esenwa C, Milstein M, Boro A, Mehler MF. Neurologic Syndromes Predict Higher In-Hospital Mortality in COVID-19. Neurology. 2021 Mar 16;96(11):e1527-e1538. doi: 10.1212/WNL.0000000000011356. Epub 2020 Dec 18. Erratum in: Neurology. 2021 Mar 16;96(11):551. PMID: 33443111; PMCID: PMC8032378.

15. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, Curtis HJ, Mehrkar A, Evans D, Inglesby P, Cockburn J, McDonald HI, MacKenna B, Tomlinson L, Douglas IJ, Rentsch CT, Mathur R, Wong AYS, Grieve R, Harrison D, Forbes H, Schultze A, Croker R, Parry J, Hester F, Harper S, Perera R, Evans

SJW, Smeeth L, Goldacre B. Factors associated with COVID-19-related death using OpenSAFELY. Nature. 2020 Aug;584(7821):430-436. doi: 10.1038/s41586-020-2521-4. Epub 2020 Jul 8. PMID: 32640463; PMCID: PMC7611074.

16. Paleiron N, Mayet A, Marbac V, Perisse A, Barazzutti H, Brocq FX, Janvier F, Dautzenberg B, Bylicki O. Impact of Tobacco Smoking on the Risk of COVID-19: A Large Scale Retrospective Cohort Study. Nicotine Tob Res. 2021 Aug 4;23(8):1398-1404. doi: 10.1093/ntr/ntab004. PMID: 33420786; PMCID: PMC7953961.

17. Patanavanich, R., Glantz, S.A. Smoking is associated with worse outcomes of COVID-19 particularly among younger adults: a systematic review and meta-analysis. *BMC Public Health* **21,** 1554 (2021). https://doi.org/10.1186/s12889-021-11579-x

18. Umnuaypornlert A, Kanchanasurakit S, Lucero-Prisno D EI, Saokaew S. Smoking and risk of negative outcomes among COVID-19 patients: A systematic review and meta-analysis. Tobacco Induced Diseases. 2021;19(February):9. doi:10.18332/tid/132411.

19. Twohig KA, Nyberg T, Zaidi A, Thelwall S, Sinnathamby MA, Aliabadi S, Seaman SR, Harris RJ, Hope R, Lopez-Bernal J, Gallagher E, Charlett A, De Angelis D, Presanis AM, Dabrera G; COVID-19 Genomics UK (COG-UK) consortium. Hospital admission and emergency care attendance risk for SARS-CoV-2 delta (B.1.617.2) compared with alpha (B.1.1.7) variants of concern: a cohort study. Lancet Infect Dis. 2021 Aug 27:S1473-3099(21)00475-8. doi: 10.1016/S1473-3099(21)00475-8. Epub ahead of print. PMID: 34461056; PMCID: PMC8397301.

20. Fisman, D. N. and A. R. Tuite (2021). "Evaluation of the relative virulence of novel SARS-CoV-2 variants: a retrospective cohort study in Ontario, Canada." Canadian Medical Association Journal 193(42): E1619-E1625.

Table 2.1 Demographic and clinical characteristics of patients with and without ESRD (N=5,761)

Variable		Non-ESRD n (%) (N=5,336)	ESRD n (%) (N=425)
Sex	Male	3018 (56.6)	243 (57.2)
Age (years)[1]		60 (45, 73)	61 (50, 71)
Age (%)	18-39	973 (18.2)	57 (13.4)
	40-49	675 (12.6)	47 (11.1)
	50-59	996 (18.7)	89 (20.9)
	60-69	1055 (19.8)	115 (27.1)
	70-79	819 (15.3)	69 (16.2)
	80+	818 (15.3)	48 (11.3)
Race/Ethnicity	White	1494 (28)	60 (14.1)
	Asian	582 (10.9)	39 (9.2)
	Other/Unknown	503 (9.4)	30 (7.1)
	Hispanic	2351 (44.1)	240 (56.5)
	Black	406 (7.6)	56 (13.2)
Area Deprivation Index[2]	Missing	870 (16.3)	33 (7.8)
	1	460 (8.6)	19 (4.5)
	2	414 (7.8)	28 (6.6)
	3	410 (7.7)	23 (5.4)
	4	529 (9.9)	40 (9.4)
	5	648 (12.1)	56 (13.2)
	6	531 (10)	60 (14.1)
	7	453 (8.5)	67 (15.8)
	8	362 (6.8)	34 (8)
	9	335 (6.3)	36 (8.5)
	10	324 (6.1)	29 (6.8)
Comorbid Conditions			
Cancer		957 (17.9)	64 (15.1)

Variable		Non-ESRD n (%) (N=5,336)	ESRD n (%) (N=425)
Major Cardiac Disease		3271 (61.3)	404 (95.1)
Valvular Cardiac Disease		1077 (20.2)	214 (50.4)
Cardiac Arrhythmias		3010 (56.4)	327 (76.9)
Peripheral Vascular Disease		628 (11.8)	163 (38.4)
Cerebrovascular		1009 (18.9)	147 (34.6)
Coagulopathy		1295 (24.3)	177 (41.6)
Anemia		816 (15.3)	165 (38.8)
Diabetes		2125 (39.8)	315 (74.1)
Drug Abuse		586 (11)	48 (11.3)
HIV/AIDS		76 (1.4)	7 (1.6)
Hypertension		3293 (61.7)	412 (96.9)
Hyperthyroidism		753 (14.1)	91 (21.4)
Liver Disease		1082 (20.3)	134 (31.5)
Chronic Neurological Conditions		1119 (21)	118 (27.8)
Acute Neurological Conditions		769 (14.4)	103 (24.2)
Obesity		1885 (35.3)	186 (43.8)
Paralysis		276 (5.2)	31 (7.3)
Chronic Psychoses		239 (4.5)	13 (3.1)
Acute Psychoses		64 (1.2)	3 (0.7)
Pulmonary Disease[3]		1897 (35.6)	205 (48.2)
Rheumatoid Arthritis/CVD		403 (7.6)	55 (12.9)
Smoking		1134 (21.3)	113 (26.6)

Variable		Non-ESRD n (%) (N=5,336)	ESRD n (%) (N=425)
Solid Organ Transplantation, excluding Kidney		194 (3.6)	35 (8.2)

Abbreviations: CVD=Collagen Vascular Disease
[1]Data are expressed as medians (interquartile ranges)
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Table 2.2 Odds ratios for ICU admission and ICU length of stay of ≥7 days among patients with ESRD (the group without ESRD is the referent)

Outcomes	OR	95% CI	p Value
ICU admission (N=5,761)			
Unadjusted	1.31	1.05, 1.64	0.015
Adjusted model 1[1]	1.23	0.98, 1.54	0.068
Adjusted model 2[2]	0.75	0.59, 0.96	0.023
ICU length of stay (<7 vs ≥7 days) (N=5,260)[3]			
Unadjusted	1.17	0.81, 1.69	0.396
Adjusted model 1[1]	1.02	0.71, 1.49	0.898
Adjusted model 2[4]	0.55	0.37, 0.82	0.003

Abbreviations: OR=odds ratio
[1]Adjusted model 1 adjusted for demographic variables sex, age category, and race/ethnicity
[2]Adjusted model 2 adjusted for demographic variables, acute neurological conditions, cardiac arrhythmias, major cardiac disease, cardiac valvular disease, coagulopathy, diabetes, and hypertension
[3]The analyses of ICU LOS were performed only among those patients discharged alive from the hospital and ICU LOS was calculated as the total days admitted to an ICU or a CCU during the hospital stay, with patients not admitted to an ICU or a CCU assigned an ICU LOS of 0 days
[4]Adjusted model 2 adjusted for demographic variables, acute neurological conditions, cardiac arrhythmias, major cardiac disease, coagulopathy, diabetes, and hypertension

Table 2.3 Univariate and multivariate logistic regression analyses of risk factors associated with ICU admission among patients without ESRD (N=5,336)

Variable		Univariate			Multivariate[1]		
		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
Age (per 10 years increase)		1.14	1.1, 1.18	<.0001	1.04	1, 1.09	0.0734
Sex	Female (referent)						
	Male	1.34	1.18, 1.53	<.0001	1.32	1.15, 1.52	0.0001
Race/ethnicity	White (referent)						
	Asian	1.28	1.02, 1.6	0.0323	1.09	0.86, 1.4	0.4698
	Black	0.82	0.62, 1.09	0.1799	0.78	0.58, 1.05	0.1059
	Hispanic	1.27	1.08, 1.48	0.0032	1.44	1.2, 1.72	<.0001
	Other/Unknown	1.30	1.03, 1.65	0.0279	1.42	1.1, 1.84	0.0067
Area Deprivation Index[2]	1	0.72	0.52, 1.01	0.0552			
	2	0.66	0.47, 0.93	0.0183			
	3	0.76	0.55, 1.07	0.1169			
	4	0.91	0.67, 1.25	0.5712			
	5	0.78	0.58, 1.06	0.1135			
	6	0.65	0.47, 0.9	0.0094			
	7	0.81	0.58, 1.12	0.1974			
	8	0.93	0.66, 1.3	0.6569			
	9	1.05	0.74, 1.47	0.7991			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		0.89	0.75, 1.06	0.1886	0.70	0.58, 0.84	0.0001
Major Cardiac Disease		2.55	2.2, 2.95	<.0001	1.76	1.48, 2.09	<.0001
Valvular Cardiac Disease		1.52	1.31, 1.77	<.0001			

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Cardiac Arrhythmias		2.46	2.14, 2.82	<.0001	1.83	1.57, 2.13	<.0001
Peripheral Vascular Disease		1.23	1.01, 1.48	0.0354			
Coagulopathy		1.84	1.6, 2.12	<.0001	1.40	1.19, 1.63	<.0001
Anemia		1.09	0.91, 1.29	0.3575	0.76	0.63, 0.93	0.0059
Diabetes		1.72	1.51, 1.95	<.0001	1.26	1.09, 1.46	0.0016
HIV/AIDS		0.68	0.37, 1.24	0.2043			
Hypertension		1.68	1.47, 1.93	<.0001			
Hyperthyroidism		1.10	0.92, 1.31	0.3116			
Chronic Neurological Conditions		1.17	1, 1.36	0.0489	0.61	0.5, 0.73	<.0001
Obesity		1.34	1.18, 1.53	<.0001	1.26	1.09, 1.46	0.0024
Paralysis		2.16	1.68, 2.77	<.0001	1.69	1.28, 2.24	0.0002
Chronic Psychoses		0.78	0.56, 1.08	0.1343			
Acute Psychoses		0.47	0.22, 0.98	0.0453			
Pulmonary Disease[4]		1.52	1.34, 1.73	<.0001	1.30	1.11, 1.52	0.0009
Rheumatoid Arthritis/CVD		1.10	0.87, 1.39	0.4418			
Smoking		1.02	0.87, 1.19	0.7954	0.77	0.64, 0.92	0.0041
Solid Organ Transplantation		1.09	0.78, 1.52	0.6180			
Liver Disease		1.26	1.09, 1.47	0.0026			
Cerebrovascular Disease		1.44	1.24, 1.68	<.0001			

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjust ed OR**	**95% CI**	**p Value**
Drug Abuse		1.00	0.81, 1.22	0.9763			
Acute Neurological Conditions		3.54	3.02, 4.15	<.0001	3.21	2.66, 3.87	<.0001

Abbreviations: OR=odds ratio, CVD=collagen vascular disease

[1]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors which were significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD

[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively

[3]For comorbid conditions the absence of the condition is the referent

[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Table 2.4 Univariate and multivariate logistic regression analyses of risk factors associated with ICU admission among patients with ESRD (N=425)

Variable		Univariate			Multivariate[1]		
		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
Age (per 10 years increase)		1.02	0.89, 1.17	0.7440	1.00	0.84, 1.19	0.9871
Sex	Female (referent)						
	Male	1.39	0.9, 2.13	0.1394	1.47	0.92, 2.35	0.1106
Race/ethnicity	White (referent)						
	Asian	2.02	0.83, 4.97	0.1235	1.34	0.49, 3.68	0.5733
	Black	1.71	0.75, 3.93	0.2051	1.60	0.65, 3.96	0.3079
	Hispanic	1.40	0.71, 2.75	0.3293	1.36	0.62, 2.98	0.4413
	Other/Unknown	1.55	0.57, 4.18	0.3879	1.11	0.37, 3.31	0.8567
Area Deprivation Index[2]	1	0.58	0.16, 2.07	0.4060			
	2	0.55	0.17, 1.7	0.2964			
	3	0.58	0.17, 1.91	0.3680			
	4	0.41	0.14, 1.2	0.1043			
	5	0.84	0.33, 2.13	0.7144			
	6	0.45	0.17, 1.19	0.1090			
	7	0.80	0.32, 1.98	0.6297			
	8	0.50	0.17, 1.5	0.2177			
	9	1.04	0.38, 2.85	0.9371			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		0.81	0.44, 1.5	0.5050	0.85	0.43, 1.68	0.6421
Major Cardiac Disease		2.48	0.72, 8.56	0.1522	1.49	0.39, 5.78	0.5601
Valvular Cardiac Disease		1.10	0.72, 1.68	0.6559			
Cardiac Arrhythmias		2.65	1.46, 4.82	0.0013	2.29	1.2, 4.36	0.0122

		Univariate			Multivariate[1]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Peripheral Vascular Disease		0.80	0.52, 1.25	0.3304			
Coagulopathy		1.81	1.18, 2.77	0.0063	1.40	0.88, 2.25	0.1597
Anemia		0.86	0.56, 1.34	0.5117	0.75	0.46, 1.23	0.2528
Diabetes		1.02	0.63, 1.65	0.9380	0.77	0.44, 1.36	0.3672
HIV/AIDS		0.41	0.05, 3.47	0.4164			
Hypertension		0.63	0.2, 1.96	0.4212			
Hyperthyroidism		1.23	0.74, 2.03	0.4183			
Chronic Neurological Conditions		0.97	0.6, 1.55	0.8868	0.74	0.42, 1.29	0.2830
Obesity		1.05	0.69, 1.61	0.8207	1.10	0.68, 1.79	0.6844
Paralysis		1.03	0.46, 2.31	0.9423	0.71	0.29, 1.76	0.4635
Chronic Psychoses		0.75	0.2, 2.76	0.6627			
Acute Psychoses		0.00		0.9865			
Pulmonary Disease[4]		1.56	1.02, 2.39	0.0388	1.85	1.09, 3.14	0.0237
Rheumatoid Arthritis/CVD		0.75	0.39, 1.45	0.3958			
Smoking		0.83	0.51, 1.34	0.4407	0.53	0.28, 0.98	0.0423
Solid Organ Transplantation		0.86	0.39, 1.89	0.7062			
Liver Disease		1.05	0.67, 1.64	0.8437			
Cerebrovascular Disease		1.01	0.65, 1.57	0.9733			
Drug Abuse		1.16	0.61, 2.23	0.6507			
Acute Neurological Conditions		3.74	2.34, 5.98	<.0001	3.59	2.12, 6.06	<.0001

Abbreviations: OR=odds ratio, CVD=collagen vascular disease

[1]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors which were significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD

[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively

[3]For comorbid conditions the absence of the condition is the referent

[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Figure 2.1 Forest plot showing the multivariate risk factors for ICU admission among patients with and without ESRD (N=5,761)
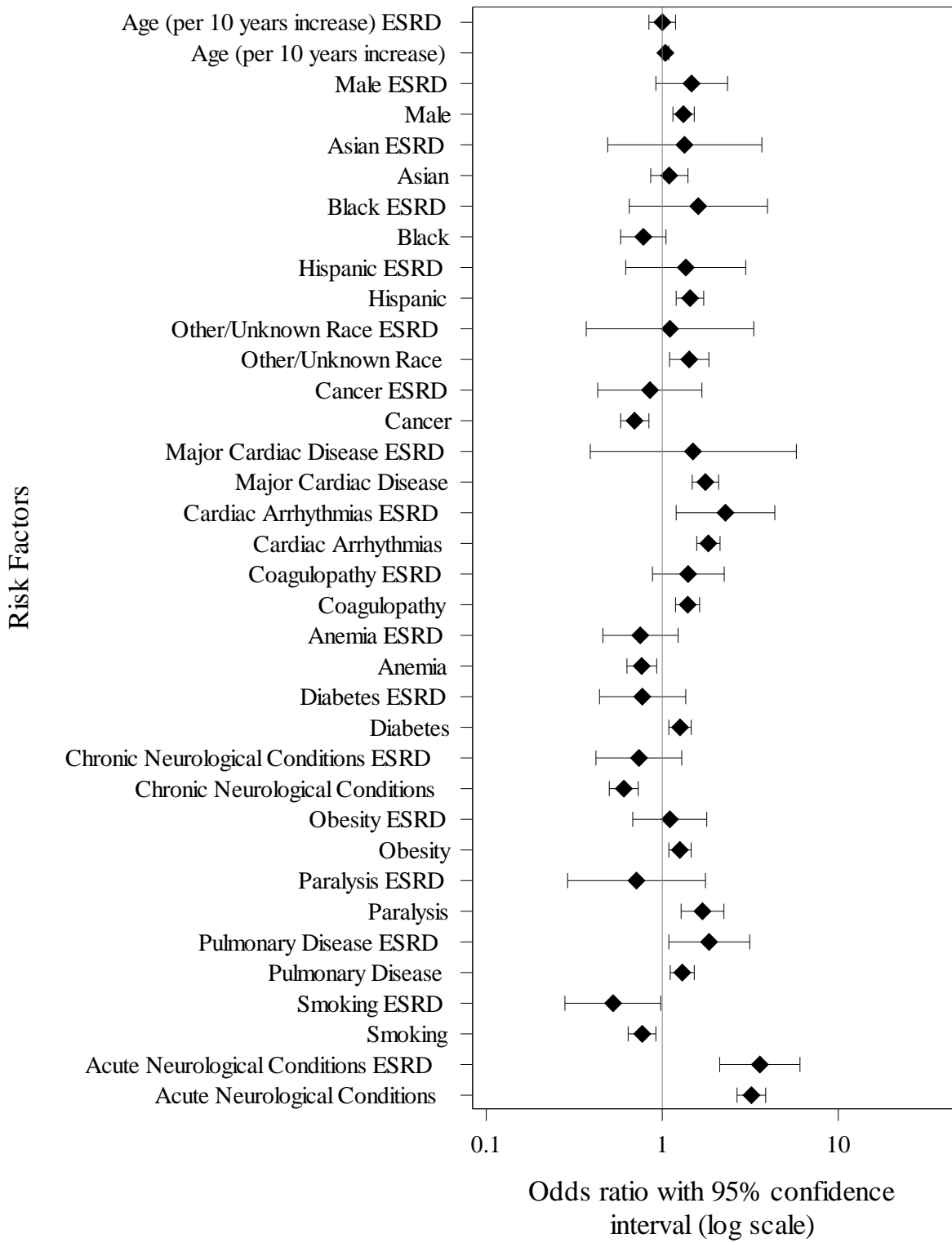
Supplemental Appendix

Table of Contents

Supplemental Table S2.1 List of ICD-10-CM codes used to define COVID-19 positive test result, ESRD, and comorbid conditions included in study

Condition	ICD-10-CM Codes
COVID-19	Patients were considered to have a positive COVID-19 test result if they were assigned one of the following logical observation identifiers names and codes (LOINC) codes: '94309-2', '94500-6', '94531-1', '94306-8', '94534-5', '94559-2', '94533-7', or '94310-0'
End Stage Renal Disease (ESRD)	Patients were classified as having ESRD if their admission included the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients with an active renal transplant but did include patients with failed kidney transplants back on long-term dialysis, by simultaneously excluding subjects with ICD-10-CM codes T86.1, T86.10, T86.13, and T86.19, and Z94.0 (we did include those with failed kidney transplants by including those with an ICD-10-CM code T86.12).
Cancer	C00, C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C30, C31, C32, C33, C34, C37, C38, C39, C40, C41, C43, C45, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57, C58, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C88, C90.0, C90.2, C91.0, C91.1, C91.5, C92.0, C92.1, C92.4, C92.5, C92.6, C92.8, C96, C97
Major Cardiac Disease	A52.0 (Cardiovascular and cerebrovascular syphilis), I09.8 (Other specified rheumatic heart diseases), I09.9 (Rheumatic heart disease, unspecified), I25.10 (Atherosclerotic heart disease of native coronary artery without angina pectoris), I25.5 (Ischemic cardiomyopathy), I42.0 (Dilated cardiomyopathy), I42.5 (Other restrictive cardiomyopathy), I42.6 (Alcoholic cardiomyopathy), I42.7 (Cardiomyopathy due to drug and external agent), I42.8 (Other cardiomyopathies), I42.9 (Cardiomyopathy, unspecified), I43 (Cardiomyopathy in diseases classified elsewhere), I45.6 (Pre-excitation syndrome), I45.9 (Conduction disorder, unspecified), I50 (Heart failure), I70,

	(Atherosclerosis) I73.1 (Thromboangiitis obliterans [Buerger's disease]), I79.2, T82.1 (Mechanical complication of cardiac electronic device), Z45.0 (Encounter for adjustment and management of cardiac device), Z95.0 (Presence of cardiac pacemaker), Z95.8 (Presence of other cardiac and vascular implants and grafts), Z95.9 (Presence of cardiac and vascular implant and graft, unspecified)
Hypertension	I11.0 (Hypertensive heart disease with heart failure), I13.0 (Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease), I13.2 (Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease), I10 (Essential (primary) hypertension), I11 (Hypertensive heart disease), I12 (Hypertensive chronic kidney disease), I13 (Hypertensive heart and chronic kidney disease), I15 (Secondary hypertension)
Cardiac Valvular Disease	I05 (Rheumatic mitral valve diseases), I06 (Rheumatic aortic valve diseases), I07(Rheumatic tricuspid valve diseases), I08 (Multiple valve diseases), I09.1, (Rheumatic diseases of endocardium, valve unspecified), I34 (Nonrheumatic mitral valve disorders), I35 (Nonrheumatic aortic valve disorders), I36 (Nonrheumatic tricuspid valve disorders), I37 (Nonrheumatic pulmonary valve disorders), I38 (Endocarditis, valve unspecified), I39 (Endocarditis and heart valve disorders in diseases classified elsewhere), Q23.0 (Congenital stenosis of aortic valve), Q23.1, (Congenital insufficiency of aortic valve), Z95.2 (Presence of prosthetic heart valve), Z95.3 (Presence of xenogenic heart valve), Z95.4 (Presence of other heart-valve replacement), I71 (Aortic aneurysm and dissection), Q23.2 (Congenital mitral stenosis), Q23.3 (Congenital mitral insufficiency),
Cardiac Arrhythmias	I47 (Paroxysmal tachycardia), I48 (Atrial fibrillation and flutter), I49 (Other cardiac arrhythmias), I44.1 (Atrioventricular block, second degree), I44.2 (Atrioventricular block, complete), I44.3 (Other and unspecified atrioventricular block), R00.0 (Tachycardia, unspecified), R00.1 (Bradycardia, unspecified), R00.8 (Other abnormalities of heart beat),

Cardiac Peripheral Vascular Disease	I73.8 (Other specified peripheral vascular diseases), I73.9 (Peripheral vascular disease, unspecified), K55.1 (Chronic vascular disorders of intestine), K55.8 (Other vascular disorders of intestine), K55.9 (Vascular disorder of intestine, unspecified), I77.1 (Stricture of artery), I79.0 (Aneurysm of aorta in diseases classified elsewhere)
CerebrovascularDisease	G45 (Transient cerebral ischemic attacks and related syndromes), G46 (Vascular syndromes of brain in cerebrovascular diseases), H34.0 (Transient retinal artery occlusion), I60 (Nontraumatic subarachnoid hemorrhage), I61 (Nontraumatic intracerebral hemorrhage), I62 (Other and unspecified nontraumatic intracranial hemorrhage), I63 (Cerebral infarction), I64, I65 (Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction), I66 (Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction), I67 (Other cerebrovascular diseases), I68 (Cerebrovascular disorders in diseases classified elsewhere), I69 (Sequelae of cerebrovascular disease)
Coagulopathy	D65 (Disseminated intravascular coagulation [defibrination syndrome]), D66 (Hereditary factor VIII deficiency), D67 (Hereditary factor IX deficiency), D68 (Other coagulation defects), D69.1 (Qualitative platelet defects), D69.3 (Immune thrombocytopenic purpura), D69.4 (Other primary thrombocytopenia), D69.5 (Secondary thrombocytopenia), D69.6 (Thrombocytopenia, unspecified)
Anemia	D50.8 (Other iron deficiency anemias), D50.9 (Iron deficiency anemia, unspecified), D51 (Vitamin B12 deficiency anemia), D52 (Folate deficiency anemia), D53 (Other nutritional anemias)
Diabetes	E10.0, E10.1, E10.2, E10.3, E10.4, E10.5, E10.6, E10.7, E10.8, E10.9, E11.0, E11.1, E11.2, E11.3, E11.4, E11.5, E11.6, E11.7, E11.8, E11.9, E12.0, E12.1, E12.2, E12.3, E12.4, E12.5, E12.6, E12.7, E12.8, E12.9, E13.0, E13.1, E13.2, E13.3, E13.4, E13.5, E13.6, E13.7, E13.8, E13.9, E14.0, E14.1, E14.2, E14.3, E14.4, E14.5, E14.6, E14.7, E14.8, E14.9
Drug Abuse	F11, F12, F13, F14, F15, F16, F18, F19, Z71.5, Z72.2

HIV/AIDS	B20 (Human immunodeficiency virus [HIV] disease)
Hypothyroidism	E00 (Congenital iodine-deficiency syndrome), E01 (Iodine-deficiency related thyroid disorders and allied conditions), E02 (Subclinical iodine-deficiency hypothyroidism), E03 (Other hypothyroidism), E89.0 (Postprocedural hypothyroidism)
Liver Disease	B18, I85, I86.4, I98.2, K70, K71.1, K71.3, K71.4, K71.5, K71.7, K72, K73, K74, K76.0, K76.2, K76.3, K76.4, K76.5, K76.6, K76.7, K76.8, K76.9, Z94.4
Chronic Neurological Conditions	F01.5 (Vascular dementia), F03.9 (Unspecified dementia), G10 (Huntingtons disease), G11 (hereditary ataxia), G12 (spinal muscular atrophy and related syndromes), G13 (systemic atrophies primarily affecting central nervous system in diseases classified elsewhere), G20 (Parkinsons disease), G21 (Secondary parkinsonism), G22, G25.4 (Drug-induced chorea), G25.5 (other chorea), G30 (Alzheimers disease), G31.2 (degeneration of nervous system due to alcohol), G31.8 (other specified degenerative diseases of nervous system), G31.9 (Degenerative disease of nervous system, unspecified), G32 (other degenerative disorders of nervous system in diseases classified elsewhere), G35 (Multiple Sclerosis), G36 (Other acute disseminated demyelination), G37 (Other demyelinating diseases of central nervous system), G40 (Epilepsy and recurrent seizures), G41, R47.0 (Dysphasia and aphasia), R56 (Convulsions, not elsewhere classified)
Acute Neurological Conditions (captured on day of index hospital admission only)	G93.1 (Anoxic brain damage, not elsewhere classified), G93.4 (other and unspecified encephalopathy)
Obesity	E66, Z68.3, Z68.4, E66.01, E66.2, Z68.4
Paralysis	G04.1 (Tropical spastic paraplegia), G11.4 (Hereditary spastic paraplegia), G80.1 (Spastic diplegic cerebral palsy), G80.2 (Spastic hemiplegic cerebral palsy), G81 (Hemiplegia and hemiparesis), G82 (Paraplegia (paraparesis) and quadriplegia (quadriparesis)), G83.0 (Diplegia of upper limbs), G83.1 (Monoplegia of lower limb), G83.2 (Monoplegia of upper limb), G83.3 (Monoplegia, unspecified), G83.4 (Cauda equina

	syndrome), G83.9 (Paralytic syndrome, unspecified)
Chronic Psychoses	F20 (Schizophrenia), F22(Delusional disorders), F23 (Brief psychotic disorder), F24 (Shared psychotic disorder), F25 (Schizoaffective disorders), F28 (Other psychotic disorder not due to a substance or known physiological condition), F30.2 (Manic episode, severe with psychotic symptoms), F31.2 (Bipolar disorder, current episode manic severe with psychotic features), F31.5 (Bipolar disorder, current episode depressed, severe, with psychotic features)
Acute Psychoses (captured on day of index hospital admission only)	F29 (Unspecified psychosis not due to a substance or known physiological condition)
Pulmonary Disease[1]	E84.0, E84.11, E84.19, E84.9, I26, I27, I27.8, I27.9, I28.0, I28.8, I28.9, J40, J41, J42, J43, J44, J45, J45.4, J45.5, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67, J68.4, J70.1, J70.3, J84.1, J84.9
Rheumatoid Arthritis, Collagen Vascular Disease	L94.0, L94.1, L94.3, M05, M06, M08, M12.0, M12.3, M30, M31.0, M31.1, M31.2, M31.3, M32, M33, M34, M35, M45, M46.1, M46.8, M46.9
Smoking	F17 (Nicotine dependence), I73.1 (Thromboangiitis obliterans [Buerger's disease]), J41 (imple and mucopurulent chronic bronchitis), J42 (Unspecified chronic bronchitis), J43 (Emphysema), J44 (Other chronic obstructive pulmonary disease), T65.2 (Toxic effect of tobacco and nicotine), Z71.6 (Tobacco abuse counseling), Z72.0 (Tobacco use)
Solid Organ Transplantation, excluding kidney	Z94.1 (Heart transplant status), Z94.2 (Lung transplant status), Z94.3 (Heart and lungs transplant status), Z94.4 (Liver transplant status), Z94.83 (Pancreas transplant status)

[1]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S2.2 In-hospital medications and high acuity treatments administered to patients with and without ESRD (N=5,761)

Medication or Treatment		Non-ESRD (N=5,336)	ESRD (N=425)
Remdesivir		1485 (27.8)	92 (21.6)
Dexamethasone		2900 (54.3)	207 (48.7)
Oral Blood Thinner		761 (14.3)	82 (19.3)
Monoclonal Antibodies		73 (1.4)	11 (2.6)
Bamlanivimab		25 (0.5)	6 (1.4)
Casirivimab		9 (0.2)	2 (0.5)
Tocilizumab		39 (0.7)	3 (0.7)
Mechanical Ventilation		1204 (22.6)	115 (27.1)
ECMO		24 (0.4)	2 (0.5)
ICU Admission		1241 (23.3)	121 (28.5)

Abbreviations: ICU=Intensive Care Unit, ECMO=extracorporeal membrane oxygenation

Supplemental Table S2.3 Univariate and multivariate logistic regression analyses of risk factors associated with ICU length of stay[1] of ≥7 days among patients without ESRD discharged alive from the hospital (N=4,886)

Variable		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
		Univariate			**Multivariate[2]**		
Age (per 10 years increase)		1.04	0.98, 1.1	0.1965	1.02	0.94, 1.09	0.6747
Sex	Female (referent)						
	Male	1.39	1.12, 1.73	0.0026	1.45	1.16, 1.83	0.0014
Race/ethnicity	White (referent)						
	Asian	1.78	1.2, 2.62	0.0038	1.72	1.14, 2.6	0.0098
	Black	0.94	0.55, 1.6	0.8252	0.90	0.52, 1.56	0.6990
	Hispanic	1.94	1.47, 2.57	<.0001	2.16	1.59, 2.95	<.0001
	Other/Unknown	2.12	1.45, 3.12	0.0001	2.20	1.46, 3.32	0.0002
Area Deprivation Index[3]	1	0.62	0.35, 1.07	0.0853			
	2	0.67	0.39, 1.17	0.1572			
	3	0.68	0.39, 1.19	0.1757			
	4	0.96	0.59, 1.56	0.8574			
	5	0.78	0.48, 1.28	0.3285			
	6	0.43	0.24, 0.77	0.0044			
	7	0.80	0.48, 1.36	0.4152			
	8	0.96	0.56, 1.62	0.8706			
	9	1.03	0.61, 1.76	0.9016			
	10 (referent)						
Comorbid Conditions[4]							
Cancer		0.70	0.51, 0.95	0.0206	0.57	0.41, 0.79	0.0007
Major Cardiac Disease		2.64	2.06, 3.39	<.0001	2.16	1.62, 2.88	<.0001
Valvular Cardiac Disease		1.04	0.8, 1.35	0.7640	0.63	0.47, 0.85	0.0023
Cardiac Arrhythmias		2.67	2.1, 3.38	<.0001	2.16	1.66, 2.8	<.0001

		Univariate			Multivariate[2]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Peripheral Vascular Disease		0.97	0.7, 1.35	0.8572			
Coagulopathy		2.06	1.65, 2.57	<.0001	1.61	1.26, 2.06	0.0001
Anemia		1.24	0.94, 1.63	0.1316			
Diabetes		1.76	1.43, 2.17	<.0001			
HIV/AIDS		1.25	0.57, 2.74	0.5804			
Hypertension		1.58	1.26, 1.98	<.0001			
Hyperthyroidism		0.92	0.67, 1.26	0.5964			
Chronic Neurological Conditions		0.83	0.63, 1.1	0.1928	0.41	0.29, 0.57	<.0001
Obesity		1.92	1.56, 2.37	<.0001	1.81	1.43, 2.27	<.0001
Paralysis		2.45	1.7, 3.53	<.0001	2.35	1.53, 3.62	<.0001
Chronic Psychoses		1.16	0.72, 1.86	0.5429			
Acute Psychoses		0.59	0.19, 1.9	0.3791			
Pulmonary Disease[5]		1.38	1.11, 1.7	0.0032	1.31	1.02, 1.68	0.0372
Rheumatoid Arthritis/CVD		1.34	0.94, 1.91	0.1081			
Smoking		0.85	0.66, 1.12	0.2479	0.71	0.53, 0.96	0.0277
Solid Organ Transplantation		1.08	0.63, 1.86	0.7743			
Liver Disease		1.36	1.07, 1.74	0.0130			
Cerebrovascular Disease		1.13	0.87, 1.48	0.3516	0.72	0.52, 1	0.0490
Drug Abuse		1.18	0.87, 1.61	0.2917			
Acute Neurological Conditions		4.08	3.21, 5.17	<.0001	4.81	3.6, 6.43	<.0001

Abbreviations: OR=odds ratio, CVD=collagen vascular disease
[1]ICU LOS was calculated as the total days admitted to ICU during the hospital stay (patients not admitted to ICU were assigned an ICU LOS of 0 days)
[2]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors which were significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD
[3]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[4]For comorbid conditions the absence of the condition is the referent
[5]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S2.4 Univariate and multivariate logistic regression analyses of risk factors associated with ICU length of stay[1] of ≥7 days among patients with ESRD discharged alive from the hospital (N=374)

Variable		OR	95% CI	p Value	Adjusted OR	95% CI	p Value
		Univariate			**Multivariate[2]**		
Age (per 10 years increase)		1.11	0.89, 1.4	0.3553	1.08	0.8, 1.45	0.6155
Sex	Female (referent)						
	Male	2.01	0.93, 4.33	0.0746	2.22	0.94, 5.24	0.0690
Race/ethnicity	White (referent)						
	Asian	7.90	0.88, 70.85	0.0647	4.41	0.42, 45.85	0.2147
	Black	8.36	0.99, 70.8	0.0513	8.70	0.91, 82.92	0.0600
	Hispanic	4.73	0.62, 36.16	0.1347	5.35	0.62, 45.88	0.1262
	Other/Unknown	4.45	0.38, 51.74	0.2326	3.00	0.22, 40.24	0.4060
Area Deprivation Index[3]	1	0.32	0.03, 3.21	0.3334			
	2	0.54	0.11, 2.71	0.4546			
	3	0.47	0.08, 2.91	0.4199			
	4	0.30	0.05, 1.81	0.1887			
	5	0.86	0.23, 3.21	0.8191			
	6	0.26	0.05, 1.3	0.1014			
	7	0.16	0.03, 0.95	0.0439			
	8	0.16	0.02, 1.5	0.1075			
	9	0.62	0.14, 2.8	0.5347			
	10 (referent)						
Comorbid Conditions[4]							
Cancer		1.19	0.47, 3.01	0.7180	1.62	0.55, 4.8	0.3804
Major Cardiac Disease		2.06	0.27, 15.86	0.4868	1.05	0.11, 10.16	0.9667
Valvular Cardiac Disease		0.65	0.31, 1.34	0.2415	0.41	0.17, 0.98	0.0455
Cardiac Arrhythmias		5.93	1.39, 25.26	0.0160	7.20	1.47, 35.13	0.0147

		Univariate			Multivariate[2]		
Variable		**OR**	**95% CI**	**p Value**	**Adjusted OR**	**95% CI**	**p Value**
Peripheral Vascular Disease		0.87	0.42, 1.82	0.7115			
Coagulopathy		1.60	0.79, 3.23	0.1952	1.13	0.49, 2.58	0.7762
Anemia		0.62	0.29, 1.33	0.2190			
Diabetes		1.39	0.58, 3.3	0.4576			
HIV/AIDS		0.00		0.9887			
Hypertension		0.48	0.1, 2.31	0.3633			
Hyperthyroidism		1.15	0.5, 2.64	0.7499			
Chronic Neurological Conditions		0.84	0.37, 1.93	0.6838	0.44	0.16, 1.23	0.1191
Obesity		1.31	0.65, 2.66	0.4495	1.32	0.59, 2.95	0.5012
Paralysis		1.33	0.38, 4.7	0.6533	1.05	0.23, 4.79	0.9475
Chronic Psychoses		0.00		0.9846			
Acute Psychoses		0.00		0.9878			
Pulmonary Disease[5]		1.67	0.81, 3.41	0.1625	1.75	0.7, 4.38	0.2288
Rheumatoid Arthritis/CVD		0.39	0.09, 1.68	0.2063			
Smoking		1.03	0.46, 2.29	0.9402	0.65	0.23, 1.79	0.4023
Solid Organ Transplantation		1.38	0.46, 4.18	0.5703			
Liver Disease		1.10	0.52, 2.34	0.8037			
Cerebrovascular Disease		1.43	0.69, 2.93	0.3344	1.06	0.42, 2.67	0.8940
Drug Abuse		0.90	0.26, 3.11	0.8680			
Acute Neurological Conditions		6.29	3.02, 13.11	<.0001	6.05	2.57, 14.26	<.0001

Abbreviations: OR=odds ratio, CVD=collagen vascular disease
[1]ICU LOS was calculated as the total days admitted to ICU during the hospital stay (patients not admitted to ICU were assigned an ICU LOS of 0 days)
[2]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors which were significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD
[3]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[4]For comorbid conditions the absence of the condition is the referent
[5]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Figure S2.1 Forest plot showing the multivariate risk factors for ICU LOS of >=7 days among patients with and without ESRD (N=5,260)
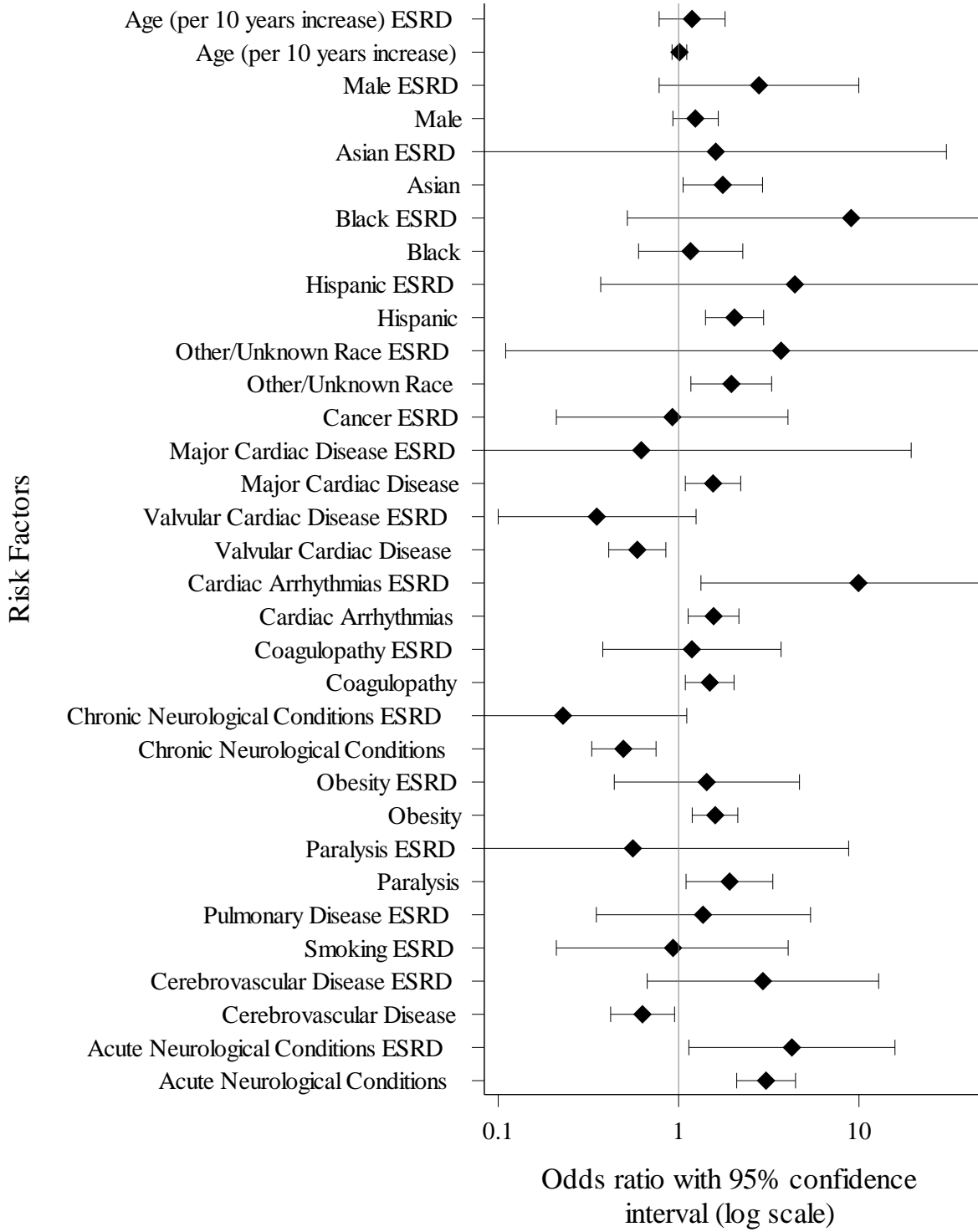
Supplemental Table S2.5 Demographic and clinical characteristics of patients admitted and not admitted to the ICU (N=5,761)

Variable		Not Admitted to ICU (N=4,399)	Admitted to ICU (N=1,362)
Sex	Male	2415 (54.9)	846 (62.1)
Age (years)[1]		59 (43, 72)	63 (51, 74)
Age (%)	18-39	878 (20)	152 (11.2)
	40-49	573 (13)	149 (10.9)
	50-59	811 (18.4)	274 (20.1)
	60-69	857 (19.5)	313 (23)
	70-79	629 (14.3)	259 (19)
	80+	651 (14.8)	215 (15.8)
Race/Ethnicity	White	1231 (28)	323 (23.7)
	Asian	461 (10.5)	160 (11.7)
	Other/Unknown	396 (9)	137 (10.1)
	Hispanic	1939 (44.1)	652 (47.9)
	Black	372 (8.5)	90 (6.6)
Area Deprivation Index[2]	Missing	701 (15.9)	202 (14.8)
	1	375 (8.5)	104 (7.6)
	2	352 (8)	90 (6.6)
	3	335 (7.6)	98 (7.2)
	4	425 (9.7)	144 (10.6)
	5	537 (12.2)	167 (12.3)
	6	473 (10.8)	118 (8.7)
	7	392 (8.9)	128 (9.4)
	8	294 (6.7)	102 (7.5)
	9	262 (6)	109 (8)
	10	253 (5.8)	100 (7.3)
Comorbid Condition			
Cancer		798 (18.1)	223 (16.4)
Major Cardiac Disease		2603 (59.2)	1072 (78.7)
Valvular Cardiac Disease		909 (20.7)	382 (28)
Cardiac Arrhythmias		2333 (53)	1004 (73.7)

Variable		Not Admitted to ICU (N=4,399)	Admitted to ICU (N=1,362)
Cardiac PVD		582 (13.2)	209 (15.3)
Cerebrovascular		823 (18.7)	333 (24.4)
Coagulopathy		993 (22.6)	479 (35.2)
Deficiency Anemia		737 (16.8)	244 (17.9)
Diabetes		1730 (39.3)	710 (52.1)
Drug Abuse		483 (11)	151 (11.1)
HIV/AIDS		69 (1.6)	14 (1)
Hypertension		2711 (61.6)	994 (73)
Hyperthyroidism		629 (14.3)	215 (15.8)
Liver Disease		888 (20.2)	328 (24.1)
Chronic Neurological Conditions		919 (20.9)	318 (23.3)
Acute Neurological Conditions		466 (10.6)	406 (29.8)
Obesity		1513 (34.4)	558 (41)
Paralysis		192 (4.4)	115 (8.4)
Chronic Psychoses		203 (4.6)	49 (3.6)
Acute Psychoses		59 (1.3)	8 (0.6)
Pulmonary Disease[3]		1499 (34.1)	603 (44.3)
Rheumatoid Arthritis/CVD		345 (7.8)	113 (8.3)
Smoking		951 (21.6)	296 (21.7)
Solid Organ Transplantation, excluding Kidney		172 (3.9)	57 (4.2)
ESRD		304 (6.9)	121 (8.9)
Remdesivir		1107 (25.2)	470 (34.5)
Dexamethasone		2094 (47.6)	1013 (74.4)
Oral Blood Thinner		575 (13.1)	268 (19.7)
Monoclonal Antibodies		47 (1.1)	37 (2.7)
Bamlanivimab		27 (0.6)	4 (0.3)
Casirivimab		10 (0.2)	1 (0.1)

Variable		Not Admitted to ICU (N=4,399)	Admitted to ICU (N=1,362)
Tocilizumab		10 (0.2)	32 (2.3)
Mechanical Ventilation		795 (18.1)	524 (38.5)
ECMO		3 (0.1)	23 (1.7)

Abbreviations: ICU=intensive care unit, CVD=Collagen Vascular Disease, ECMO=extracorporeal membrane oxygenation
[1]Data are expressed as medians (interquartile ranges)
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Chapter 3 Risks of death and readmission within 30 days post-discharge for end-stage renal disease patients post-hospitalization for COVID-19. A retrospective cohort study in 5 California medical centers.

Introduction

Since December of 2019, infection with SARS-CoV-2, the virus that causes COVID-19, has led to the most serious infectious disease pandemic since the influenza pandemic of 1918-1920. In the United States, over 45.6 million cases of COVID-19 were diagnosed from February 2020 to October27, 2021, resulting in 739,259 deaths. In the state of California, over 4.8 million cases of COVID-19 were diagnosed in the same time period, resulting in 71,800 deaths and 4,038 individuals presently hospitalized (1). While the majority of individuals affected by COVID-19 exhibit only mild symptoms that do not require hospitalization, many require hospitalization, with the most ill patients needing intensive care unit (ICU) admission, mechanical ventilation and extracorporeal membrane oxygenation (ECMO) treatment.

Infection is the second most commonly reported cause of death in the ESRD population (2). Annual death rates from pneumonia and sepsis are substantially higher among ESRD patients than among the general population (3). ESRD patients have a compromised and poorly regulated immune system, which may increase susceptibility to bacterial and viral infections, including the SARS-COV-2 virus (4).

In a retrospective study of 1,344 adult patients discharged from the New York-Presbyterian/Weill Cornell Medical Center, or the Lower Manhattan Hospital, or an emergency room (ER) at one of these locations between March 3 through May 15, 2020, Kingery et al (5) investigated the outcomes: return to ER, re-hospitalization, and death within 30 days post-hospitalization. Their study found a significantly higher hazard of return to the ER (adjusted hazard ratio 1.93, 95% CI 1.23-3.03) and re-hospitalization (adjusted hazard ratio 2.94, 95% CI 1.78-4.84, p <0.001) among individuals post-discharge for COVID-19 infection with ESRD

compared to those without, but no difference in the hazard of death within 30 days post-discharge for these two groups.

We aimed to further examine the post-hospital discharge outcomes of ESRD patients admitted for COVID-19 in a diverse Western United States population. A study by Donnelly *et al* (6) of patients admitted with COIVD-19 to the Veteran's Affairs Healthcare System found that risk for adverse clinical outcomes following a hospitalization for COVID-19 is highest in the 7-10 days following discharge and the 30 day period following hospital discharge is a key one. We sought to compare the outcomes death and readmission within 30 days post-hospitalization for COVID-19 in ESRD patients to that of individuals without ESRD, at any of 5 tertiary care University of California academic hospitals.

Materials and Methods

We used the University of California COVID Research Database (UC CORDS) which is a large, harmonized database provided by the UC Health Data Warehouse (UCHDW) that includes patients from the 5 tertiary care, academic hospitals of the University of California (UC Davis, UC Irvine, UC Los Angeles, UC San Diego and UC San Francisco). The primary, secondary outcomes of our study were death, readmission, respectively, within 30 days post-discharge. This retrospective study included adults with and without ESRD, who were ≥18 years of age when first hospitalized for COVID-19 (qualifying hospital admission), and who tested positive for COVID-19 by polymerase chain reaction nasal swab within 30 days prior to or at any time during their hospital stay at any of the 5 University of California medical centers. We included those admitted between February 12, 2020 and September 6, 2021, discharged alive by September 7, 2021. Individuals were excluded from the study if, for their qualifying hospital

admission, they were transferred in from a hospital outside the University of California hospital system (N=556), transferred out of the University of California hospital system (N=136), or admitted to an inpatient obstetric service (N=146). The study end date was October 7, 2021. Individuals were classified as having ESRD if their hospital admission included the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients with an active renal transplant from the ESRD group, but included patients with failed kidney transplants who were back on long-term dialysis. See **supplemental Table S3.1** for further details.

Demographic and baseline characteristics included age in year at qualifying hospital admission, sex, race and ethnicity. Age was categorized as 18-39 (the referent), 40-49, 50-59, 60-69, 70-79 and 80+ years. Self-reported data on race and ethnicity were combined and categorized as White (White, non-Hispanic, the referent), Hispanic (White, Hispanic), Black, Asian, and Other/Unknown. In gender analyses, female was the referent.

Comorbid conditions identified in individuals prior to or on their date of their qualifying hospital admission included collagen vascular disease, immune system disease, including lupus, scleroderma and rheumatoid arthritis, hypothyroidism, drug use disorders, anemia, cerebrovascular disease, diabetes, hypertension, obesity, cardiac valvular disease, cardiac arrhythmias, cardiac peripheral vascular disease, major cardiac disease, HIV/AIDS, liver disease, paralysis cancer, chronic psychoses, chronic neurological conditions, pulmonary disease, solid organ transplantation (excluding kidney transplants) and smoking status (smoker/ever-smoker vs never smoker). If encephalopathy, acute psychosis was diagnosed on the day of qualifying

hospital admission, we considered these an acute neurological condition, acute psychosis, respectively. We grouped asthma and chronic obstructive pulmonary disease (COPD) into a single pulmonary disease factor. Individuals were classified as having or not having these comorbid conditions, using the ICD-10-CM codes listed in **supplemental Table S3.1**. For each comorbid condition, the absence of the condition was the referent.

Given the socioeconomic diversity of California, we also included the area deprivation index (ADI) as a factor in our analyses. The ADI for a given neighborhood (census block group) is a measure of relative socioeconomic disadvantage (7, 8) and is calculated by comparing income, education, employment, and housing for that neighborhood against the mean values of these factors for the given state (ADIs are state specific). ADIs are calculated in deciles with an ADI of one signifying a neighborhood least socioeconomically disadvantaged and an ADI of ten signifying a neighborhood which is most socioeconomically disadvantaged. Individuals in the UC CORDS database were assigned an ADI based upon their residence zip code. In our study, 8.3% of the ESRD patients and 16.6% of those without ESRD, were missing an ADI, which caused a reduction in the sample size available for our analysis of readmission within 30 days post-discharge, for which ADI was included as a factor.

Medications administered most likely for COVID-19 treatment to patients during their qualifying hospital stay were queried, including dexamethasone, remdesivir, oral anticoagulants and monoclonal antibodies against SARS-CoV-2. Information was also collected on the use of mechanical ventilation and extracorporeal membrane oxygenation (ECMO) treatment for patients during their hospital stay, as indicators of disease severity.

We utilized simple and multiple Cox proportional hazards regression models to analyze each of the study outcomes. In addition to unadjusted models, two adjusted Cox proportional hazards regression models for death and readmission within 30 days post-discharge were analyzed. Model 1 included the demographic variables sex, age category, and race/ethnicity. Model 2 included the demographic variables plus any comorbid conditions associated at the p = 0.15 level with both the outcome and the study exposure, and which caused a ≥ 10% change in the unadjusted exposure/outcome hazard ratio when added as a factor to the unadjusted Cox proportional hazards regression model.

Backward multivariate Cox proportional hazards regression models were utilized to determine independent risk factors associated with death within 30 days post-discharge among all individuals, and readmission within 30 days, separately among individuals with and without ESRD. Risk factors for the demographic variables sex, age (per 10 years increase), race/ethnicity, and comorbid conditions with hazard ratios significant at the p = 0.05 level in two-sided tests were retained in each of the multivariate models.

Sample size calculations for the primary outcome of the study, death within 30 days post-discharge, were performed as follows: a Cox regression of the log hazard ratio on the covariate presence/absence of ESRD with a standard deviation of 0.2332 based on a sample of 4,186 observations achieves 80% power at a 0.05 significance level to detect a hazard ratio of 2.4 (regression coefficient equal to 0.8755). The sample size was adjusted since a multiple regression of the variable of interest on the other covariates in the Cox regression is expected to have an R-Squared of 0.1. The sample size was adjusted for an anticipated rate of death within 30 days post-discharge for Covid-19 infection of 0.05 (9).

This study was granted an exemption for human subject's protection by the UC Davis IRB Board (protocol# 1604619-1).

Results

After applying the study inclusion and exclusion criteria, a total of 5,260 individuals were hospitalized between February 12, 2020 and September 6, 2021, with a diagnosis of COVID-19 either within 30 days prior to or during their index hospitalization and were discharged alive. Of these, 425 (7.4%) had ESRD and 5,336 (92.6%) did not. Of the 5,260 individuals, 213 (4.2%) died within 30 days post-discharge, 24 (6.4%) in the ESRD group and 189 (3.9%) in the non-ESRD group.

The demographic and clinical characteristics for individuals with and without ESRD prior to hospital admission discharged from the hospital alive are provided in **Table 3.1**. ESRD patients were more likely than those not on dialysis to live in a more socioeconomically disadvantaged census tract, to self-identify as either Hispanic (57.8% vs 44.0%) or Black (12.8% vs 7.7%), to be smokers (25.9% vs 21.1%), to be obese (43.9% vs 35.7%), and to have more comorbid conditions. The in-hospital medications and high acuity treatments administered for COVID-19 to patients during their qualifying hospital admission, by study exposure group, are provided in **supplemental Table S3.2**. The baseline characteristics of those included in the study, and the medications and treatments administered to them in hospital, by alive and expired status 30 days post-discharge, are provided in **supplemental Table S3.5** and **supplemental Table S3.6**. Those who died within 30 days post-discharge were older (median age 60.5 vs 58) more likely

to be male (59.6% vs 55.8%) and to self-identify as White (32.4% to 26.8%) or Asian (18.8% to 10.2%).

The percentage of patients with and without ESRD who were discharged alive from the hospital and who died or were readmitted within 30 days post-discharge are shown in **Table 3.2.** The rates of death (6.4%) and readmission (17.4%) within 30 days post-discharge in the ESRD group were almost twice the corresponding rates in the non-ESRD group. Unadjusted and multivariable-adjusted hazard ratios for death and hospital readmission within 30 days post-discharge among those with and without ESRD are provided in **Table 3.3**. After determining the factors to be included in our adjusted model 2 analyses, we found that compared to those without kidney failure, ESRD patients had a significantly higher hazard of death within 30 days post-discharge in the unadjusted analysis, but not in the analysis adjusted for demographic variables and comorbid conditions (adjusted hazard ratio 1.14, 95% CI 0.72, 1.81). The hazard of readmission within 30 days post-discharge, however, was significantly higher for ESRD patients in both the unadjusted analysis and in the adjusted analysis (adjusted hazard ratio 1.43, 95% CI 1.06, 1.91, p=0.017).

The analysis of risk factors for death within 30 days post-discharge among all individuals included in the study is shown in **Table 3.4** and in **Figure 3.1**. We found acute neurological conditions at the time of qualifying hospital admission to be the factor most associated with risk of death in the 30 day period post-discharge, followed by age (per 10 years increase), Asian and Hispanic race/ethnicity, cancer, major cardiac disease, cardiac valvular disease, and coagulopathy. We found solid organ transplantation to be associated with substantially lower

risk of death in the above period, as well as, to a lesser extent, black race. Each of the above factors, with the exception of black race, was significant in both univariate and multivariate analyses.

The analyses of risk factors for readmission within 30 days post-discharge among individuals with and without ESRD are shown in **supplemental Table S3.3** and **supplemental Table S3.4**, and in **supplemental Figure S3.1**. Among those without ESRD, we found cancer to be the factor most significantly associated with risk of readmission in the 30 day period post-discharge, followed by major cardiac disease, coagulopathy, anemia, and smoking. Each of these factors was significant in both univariate and multivariate analyses. Age (per 10 years increase) was associated with lower risk of this outcome.

Among ESRD patients, we found peripheral vascular disease to be associate with significantly higher risk of readmission within 30 days, while diabetes was associated with a significantly lower risk of this outcome. Both of these factors were significant in both univariate and multivariate analyses. Some factors were found to be associated with different risks of readmission within 30 days between the ESRD and the non-ESRD groups. These included the factors Asian race, Black race, and Other/unknown race, cancer, peripheral vascular disease, coagulopathy, anemia, and diabetes, with the factors Asian race, coagulopathy, and anemia associated with a qualitatively different risk of readmission within 30 days between the ESRD and the non-ESRD groups.

Discussion

Using a large database that spans the five academic medical centers of the University of California, we sought to determine if ESRD was independently associated with a higher risk for death and readmission within 30 days post-discharge for those diagnosed with COVID-19.

Our findings that ESRD status was independently associated with a higher risk of hospital readmission but not a higher risk of death within 30 days after hospital discharge for COVID-19 agreed with the findings of a recent study by Kingery *et al* (5). The adjusted hazard ratio which we found for hospital readmission within 30 days, however, was smaller in magnitude and more precise than that found by Kingery *et al* (adjusted hazard ratio 1.43, 95% CI 1.06, 1.91 verses adjusted hazard ratio 2.94, 95% CI 1.78-4.84). The 95% confidence intervals found for the adjusted hazard ratios in the two studies overlap, so the actual hazard ratios in the two studies may in fact be identical. One possible reason for the difference in the estimated hazard ratios for risk of readmission within 30 days is that since different comorbid conditions were included in each of the two studies, some degree of residual confounding may exist in the results of Kingery *et al*. Other possible explanations are that the difference in the estimated hazard ratios is due to the different periods, patient cohorts, or hospitals studied. Kingery *et al* studied patients hospitalized early in the pandemic at two New York hospitals, while we studied patients hospitalized over many months of the pandemic at five California hospitals. Patients receiving hemodialysis for ESRD have a high 30-day readmission rate, and the reason for readmission is not necessarily related to the index hospitalization (JASN, Lin et al, 2019 30(2), 323-35). With COVID-19 related hospitalizations, we see a similar pattern. In our analysis, we were unable to evaluate the relatedness of the readmission with the index hospitalization.

We identified factors independently associated with a higher risk of death within 30 days post-discharge. We found a diagnosis of an acute neurological decline, such as acute encephalopathy, at the time of the qualifying hospital admission to be the factor most associated with higher risk of death within 30 days after hospital discharge. Other studies have found neurological conditions to be associated with a poor outcome among patients hospitalized with COVID-19, including those of Chou *et al* (10) and Eskandar *et al* (11). In two previous studies, we also found acute neurological conditions to be significantly associated with four additional outcomes: higher risk of in-hospital death, hospital length of stay of >= 7 days, ICU admission, and ICU length of stay of >= 7 days.

We found strikingly strong univariate and multivariate associations of non-renal solid organ transplantation with lower risk of death within 30 days post-discharge. Individuals with non-renal solid organ transplants may have a substantially reduced incidence of death within the 30 days period post-discharge due to more stable support at home or more resources to continue home-based care upon hospital discharge. Also, since patients receiving transplants of any type are usually the healthiest of patients with that particular disease process, there may still be residual confounding.

We found numerous factors to be independently associated with a higher risk of readmission within 30 days post-discharge. Of particular interest were factors found to be associated with different risks of readmission within 30 days between the ESRD group and the non-ESRD group. However, it is important to understand to what extent these factors might be associated with an increased risk of long-haul COVID-19, a collection of illnesses, including fatigue, pulmonary conditions, and neurological conditions, which may develop in individuals even after hospital

discharge and recovery from the acute SARS-CoV2 viral infection. The associations between the above factors and long-haul COVID-19, by ESRD status, are also important to understand in future studies.

The strengths of this study include its large cohort size and the extensive geographical and population range covered by the 5 academic medical centers. We likewise included an extensive number of comorbid conditions, including acute neurological conditions and coagulopathy, and we were able to capture the key therapeutics used to treat COVID-19 patients. To our knowledge this is one of the few studies which has investigated the risks for post-hospitalization death and hospital readmission in ESRD patients initially admitted for COVID-19.

Like all studies of this kind, the retrospective nature is a limitation. Additional limitations include that comorbidity ascertainment was performed using diagnostic codes, which vary in their degree of accuracy and completeness, and which we were not able to validate with chart review due to the pseudonymized nature of the dataset. Additionally, this study spans many months through the pandemic, and patient care management with increased experience with COVID-19 care may have changed clinical practices over time, possibly resulting in aggregation bias. The wider availability and use of COVID-19 vaccines over the study period could also conceivably have contributed to aggregation bias. Given the nature of the UC CORDS database, it was also not possible to study some key variables, including COVID-19 symptoms, blood type, vaccination status, as well as personal health habits such as masking, hand washing and social distancing practices, all of which might have affected outcomes for individuals in the 30 day period post hospitalization for COVID-19.

ESRD patients have many of the comorbid conditions linked with worse outcomes from COVID-19 and are more frequently readmitted post-hospitalization. The year 2018 rate of hospital readmissions within 30 days for all-cause index hospitalizations for US Medicare beneficiaries receiving hemodialysis was 34% (12), while the corresponding year 2018 readmission rate for all California hospital patients was 14.8% (13). ESRD patients in our study had a rate of readmission within 30 days for COVID-19 index hospitalizations that was almost double that of the readmission rate for those in the non-ESRD group, similar to the difference in rates listed above for all-cause index hospitalizations. It is not unexpected therefore, that we found presence of ESRD, upon adjusting for demographic variables and comorbid conditions, to be independently associated with higher risk of readmission within 30 days for patients hospitalized with COVID-19. However, possibly due to the immune system compromise of these patients, and the resulting reduction of cytokine storms and systemic inflammation, we also found that presence of ESRD was not independently associated with risk for death within 30 days post-hospitalization. Further study of the etiology of long-haul COVID-19 and of ESRD patients post hospitalization for COVID-19 are needed to ascertain to what extent long-haul COVID-19 impacts clinical outcomes for these patients.

Data Availability Statement
The detailed pseudonymized patient data used for this study are potentially re-identifiable and are therefore not shared.

References

1. New York Times COVID-19 statistics
https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html

2. Harris, Randall E. Epidemiology of Chronic Disease pages 471-488 yr

3. Jaber BL Bacterial infections in hemodialysis patients: pathogenesis and prevention Kidney Int 2005 Vol. 67 Issue 6 Pages 2508-19 Accession Number: 15882306 DOI: 10.1111/j.1523-1755.2005.00364.x https://www.ncbi.nlm.nih.gov/pubmed/15882306

4. Vaziri ND, Pahl MV, Crum A and Norris K Effect of uremia on structure and function of immune system J Ren Nutr 2012 Vol. 22 Issue 1 Pages 149-56 Accession Number: 22200433 PMCID: PMC3246616 DOI: 10.1053/j.jrn.2011.10.020
https://www.ncbi.nlm.nih.gov/pubmed/22200433

5. Kingery JR, Bf Martin P, Baer BR, Pinheiro LC, Rajan M, Clermont A, Pan S, Nguyen K, Fahoum K, Wehmeyer GT, Alshak MN, Li HA, Choi JJ, Shapiro MF, McNairy ML, Safford MM, Goyal P. Thirty-Day Post-Discharge Outcomes Following COVID-19 Infection. J Gen Intern Med. 2021 Aug;36(8):2378-2385. doi: 10.1007/s11606-021-06924-0. Epub 2021 Jun 7. PMID: 34100231; PMCID: PMC8183585.

6. Donnelly JP, Wang XQ, Iwashyna TJ, Prescott HC. Readmission and Death After Initial Hospital Discharge Among Patients With COVID-19 in a Large Multihospital System. JAMA. 2021 Jan 19;325(3):304-306. doi: 10.1001/jama.2020.21465. PMID: 33315057; PMCID: PMC7737131.

7. University of Wisconsin School of Medicine Public Health. 2015 Area Deprivation Index v2.0. Downloaded from https://www.neighborhoodatlas.medicine.wisc.edu

8. Kind AJH, Buckingham WR. Making Neighborhood-Disadvantage Metrics Accessible - The Neighborhood Atlas. N Engl J Med. 2018 Jun 28;378(26):2456-2458. doi: 10.1056/NEJMp1802313. PMID: 29949490; PMCID: PMC6051533.

9. PASS 2019 Power analysis and sample size www.ncss.com

10. Chou SH, Beghi E, Helbok R, *et al*. Global Incidence of Neurological Manifestations Among Patients Hospitalized With COVID-19—A Report for the GCS-NeuroCOVID Consortium and the ENERGY Consortium. *JAMA Netw Open.* 2021;4(5):e2112131. doi:10.1001/jamanetworkopen.2021.12131

11. Eskandar EN, Altschul DJ, de la Garza Ramos R, Cezayirli P, Unda SR, Benton J, Dardick J, Toma A, Patel N, Malaviya A, Flomenbaum D, Fernandez-Torres J, Lu J, Holland R, Burchi E, Zampolin R, Hsu K, McClelland A, Burns J, Erdfarb A, Malhotra R, Gong M, Semczuk P, Gursky J, Ferastraoaru V, Rosengard J, Antoniello D, Labovitz D, Esenwa C, Milstein M, Boro A, Mehler MF. Neurologic Syndromes Predict Higher In-Hospital Mortality in COVID-19. Neurology. 2021

Mar 16;96(11):e1527-e1538. doi: 10.1212/WNL.0000000000011356. Epub 2020 Dec 18. Erratum in: Neurology. 2021 Mar 16;96(11):551. PMID: 33443111; PMCID: PMC8032378.

12. California Office of Statewide Health Planning and Development (OSHPD) CH HS open data URL: https://data.chhs.ca.gov/dataset/25e1dff8-d810-4391-baf8-05fb01a1359b/resource/8dd44ad7-9e78-4c1a-9910-f58a47e402af/download/allcauseunplanned30-dayhospitalreadmissionratecalifornia2011_2019.csv

13. United States Renal Data System (USRDS) Year 2020 Annual Data Report figure 4.13 URL: https://adr.usrds.org/2020/end-stage-renal-disease/4-hospitalization

Table 3.1 Demographic and clinical characteristics of patients discharged from the hospital alive with and without ESRD (N=5,260)

Variable		Non-ESRD (N=4,886)	ESRD (N=374)
Sex	Male	2732 (55.9)	209 (55.9)
Age (years)[1]		60 (45, 73)	61 (50, 71)
Age (%)	18-39	959 (19.6)	55 (14.7)
	40-49	655 (13.4)	42 (11.2)
	50-59	951 (19.5)	79 (21.1)
	60-69	956 (19.6)	100 (26.7)
	70-79	701 (14.3)	57 (15.2)
	80+	664 (13.6)	41 (11)
Race/Ethnicity	White	1374 (28.1)	50 (13.4)
	Asian	517 (10.6)	36 (9.6)
	Other/Unknown	469 (9.6)	24 (6.4)
	Hispanic	2152 (44)	216 (57.8)
	Black	374 (7.7)	48 (12.8)
Area Deprivation Index[2]	Missing	809 (16.6)	31 (8.3)
	1	416 (8.5)	15 (4)
	2	384 (7.9)	28 (7.5)
	3	378 (7.7)	21 (5.6)
	4	480 (9.8)	32 (8.6)
	5	588 (12)	50 (13.4)
	6	473 (9.7)	54 (14.4)
	7	412 (8.4)	58 (15.5)
	8	341 (7)	30 (8)
	9	308 (6.3)	33 (8.8)
	10	297 (6.1)	22 (5.9)
Comorbid Condition			
Cancer		861 (17.6)	58 (15.5)
Major Cardiac Disease		2870 (58.7)	353 (94.4)
Valvular Cardiac Disease		939 (19.2)	179 (47.9)
Cardiac Arrhythmias		2639 (54)	280 (74.9)

Variable		Non-ESRD (N=4,886)	ESRD (N=374)
Cardiac PVD		561 (11.5)	143 (38.2)
Cerebrovascular		869 (17.8)	126 (33.7)
Coagulopathy		1111 (22.7)	148 (39.6)
Deficiency Anemia		736 (15.1)	147 (39.3)
Diabetes		1892 (38.7)	277 (74.1)
Drug Abuse		556 (11.4)	36 (9.6)
HIV/AIDS		73 (1.5)	6 (1.6)
Hypertension		2929 (59.9)	362 (96.8)
Hyperthyroidism		667 (13.7)	80 (21.4)
Liver Disease		971 (19.9)	114 (30.5)
Chronic Neurological Conditions		964 (19.7)	99 (26.5)
Acute Neurological Conditions		554 (11.3)	76 (20.3)
Obesity		1746 (35.7)	164 (43.9)
Paralysis		231 (4.7)	26 (7)
Chronic Psychoses		224 (4.6)	11 (2.9)
Acute Psychoses		62 (1.3)	3 (0.8)
Pulmonary Disease[3]		1674 (34.3)	177 (47.3)
Rheum Arthritis/CVD		369 (7.6)	49 (13.1)
Smoking		1029 (21.1)	97 (25.9)
Solid Organ Transplantation, excluding Kidney		178 (3.6)	34 (9.1)

Abbreviations: CVD=Collagen Vascular Disease
[1]Data are expressed as medians (interquartile ranges)
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Table 3.2 Percentage of patients with and without ESRD who were discharged alive from the hospital and who died or were readmitted within 30 days post-discharge (N=5,260)

Variable		Non-ESRD (N=4,886)	ESRD (N=374)
Died within 30 days		189 (3.9)	24 (6.4)
Hospital readmission within 30 days		436 (8.9)	65 (17.4)

Table 3.3 Hazard ratios for post-discharge outcomes for patients with ESRD (the group without ESRD is the referent)

Outcomes	OR	95% CI	p Value
Death within 30 days post-discharge (N=5,260)			
Unadjusted	1.68	1.1, 2.56	0.017
Adjusted model 1[1]	1.72	1.12, 2.64	0.013
Adjusted model 2[2]	1.14	0.72, 1.81	0.563
Readmission within 30 days post-discharge (N=4,420)[3]			
Unadjusted	2.02	1.56, 2.62	P < 0.001
Adjusted model 1[1]	1.97	1.51, 2.57	P < 0.001
Adjusted model 2[4]	1.43	1.06, 1.91	0.017

Abbreviations: HR=hazard ratio
[1]Adjusted model 1 adjusted for demographic variables sex, age category, and race/ethnicity
[2]Adjusted model 2 adjusted for demographic variables, acute neurological conditions, chronic neurological conditions, anemia, peripheral vascular disease, cardiac arrhythmias, major cardiac disease, cardiac valvular disease, cerebrovascular disease, coagulopathy, diabetes, hypertension, hyperthyroidism, obesity, paralysis, pulmonary disease, and transplantation
[3]Sample size for this analysis reduced due to 840 missing values for factor area deprivation index
[4]Adjusted model 2 adjusted for demographic variables, area deprivation index, chronic neurological conditions, anemia, rheumatoid arthritis/collagen vascular disease, peripheral vascular disease, cardiac arrhythmias, major cardiac disease, cardiac valvular disease, cerebrovascular disease, coagulopathy, hypertension, liver disease, pulmonary disease, and smoking

Table 3.4 Univariate and multivariate Cox proportional hazards regression analyses of risk factors associated with death within 30 days post-discharge among all individuals (N=5,260)

Variable		Univariate			Multivariate[1]		
		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
Age (per 10 years increase)		1.85	1.67, 2.04	<.0001	1.56	1.4, 1.74	<.0001
Sex	Female (referent)						
	Male	1.17	0.89, 1.53	0.2715	1.20	0.91, 1.59	0.1927
Race/ethnicity	White (referent)						
	Asian	1.52	1.03, 2.24	0.0365	1.61	1.09, 2.39	0.0178
	Black	0.48	0.25, 0.94	0.0321	0.69	0.35, 1.34	0.2733
	Hispanic	0.65	0.47, 0.9	0.0100	1.57	1.11, 2.22	0.0107
	Other/Unknown	0.79	0.48, 1.32	0.3717	1.45	0.87, 2.43	0.1562
Area Deprivation Index[2]	1	0.94	0.48, 1.84	0.8499			
	2	0.77	0.38, 1.58	0.4828			
	3	0.97	0.49, 1.92	0.9198			
	4	0.96	0.5, 1.84	0.8990			
	5	1.11	0.6, 2.05	0.7314			
	6	1.01	0.53, 1.92	0.9644			
	7	0.59	0.28, 1.23	0.1579			
	8	0.51	0.22, 1.17	0.1135			
	9	0.94	0.46, 1.92	0.8677			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		2.84	2.15, 3.75	<.0001	2.03	1.52, 2.7	<.0001
Major Cardiac Disease		5.09	3.33, 7.78	<.0001	2.05	1.31, 3.22	0.0018
Valvular Cardiac Disease		2.46	1.87, 3.24	<.0001	1.40	1.05, 1.86	0.0216
Cardiac Arrhythmias		2.40	1.76, 3.27	<.0001			
Peripheral Vascular Disease		1.91	1.39, 2.63	<.0001			
Coagulopathy		2.42	1.84, 3.17	<.0001	1.59	1.2, 2.11	0.0013

Variable		Univariate			Multivariate[1]		
		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
Anemia		1.45	1.05, 2.01	0.0224			
Diabetes		1.42	1.09, 1.86	0.0100			
HIV/AIDS		0.31	0.04, 2.18	0.2377			
Hypertension		3.87	2.62, 5.73	<.0001			
Hyperthyroidism		1.63	1.18, 2.27	0.0034			
Chronic Neurological Conditions		3.35	2.56, 4.39	<.0001			
Acute Neurological Conditions		6.62	5.06, 8.68	<.0001	3.65	2.75, 4.85	<.0001
Obesity		0.56	0.41, 0.77	0.0003			
Paralysis		2.05	1.29, 3.25	0.0022			
Chronic Psychoses		0.83	0.41, 1.69	0.6132			
Acute Psychoses		0.37	0.05, 2.64	0.3215			
Pulmonary Disease[4]		1.38	1.05, 1.81	0.0193			
Rheumatoid Arthritis/CVD		1.27	0.81, 2	0.2945			
Smoking		1.22	0.89, 1.66	0.2136			
Solid Organ Transplantation		0.11	0.02, 0.79	0.0279	0.10	0.01, 0.73	0.0230
Liver Disease		1.15	0.84, 1.59	0.3831			
Cerebrovascular Disease		2.49	1.88, 3.29	<.0001			
Drug Abuse		0.55	0.32, 0.94	0.0302			

Abbreviations: HR=hazard ratio, CVD=collagen vascular disease
[1]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]For comorbid conditions the absence of the condition is the referent
[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Figure 3.1 Forest plot showing the multivariate risk factors for death within 30 days post-hospital discharge among all patients (N=5,260)

hazard ratio with 95% confidence interval (log scale)
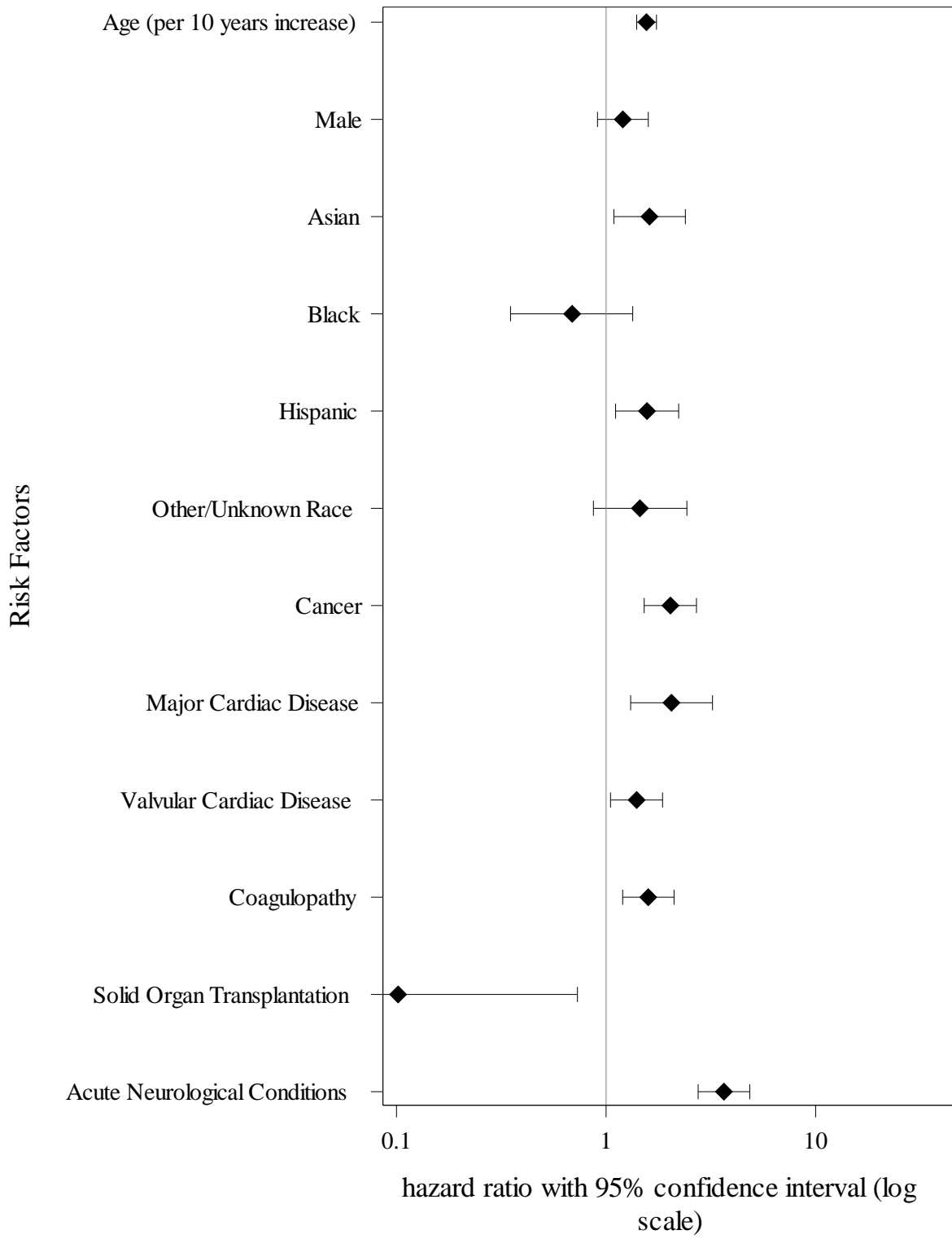
Supplemental Appendix

Table of Contents

Supplemental Table S3.1 List of ICD-10-CM codes used to define COVID-19 positive test result, ESRD, and comorbid conditions included in study

Condition	ICD-10-CM Codes
COVID-19	Patients were considered to have a positive COVID-19 test result who were assigned one of the following logical observation identifiers names and codes (LOINC) codes: '94309-2', '94500-6', '94531-1', '94306-8', '94534-5', '94559-2', '94533-7', or '94310-0'
End Stage Renal Disease (ESRD)	Patients were classified as having ESRD if their admission included the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) code N18.6. We excluded patients with an active renal transplant but did include patients with failed kidney transplants who were back on long-term dialysis, by simultaneously excluding subjects with ICD-10-CM codes T86.1, T86.10, T86.13, and T86.19, and Z94.0 (we did include those with failed kidney transplants by including those with an ICD-10-CM code T86.12).
Cancer	C00, C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C30, C31, C32, C33, C34, C37, C38, C39, C40, C41, C43, C45, C46, C47, C48, C49, C50, C51, C52, C53, C54, C55, C56, C57, C58, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73, C74, C75, C76, C77, C78, C79, C80, C81, C82, C83, C84, C85, C86, C88, C90.0, C90.2, C91.0, C91.1, C91.5, C92.0, C92.1, C92.4, C92.5, C92.6, C92.8, C96, C97
Major Cardiac Disease	A52.0 (Cardiovascular and cerebrovascular syphilis), I09.8 (Other specified rheumatic heart diseases), I09.9 (Rheumatic heart disease, unspecified), I25.10 (Atherosclerotic heart disease of native coronary artery without angina pectoris), I25.5 (Ischemic cardiomyopathy), I42.0 (Dilated cardiomyopathy), I42.5 (Other restrictive cardiomyopathy), I42.6 (Alcoholic cardiomyopathy), I42.7 (Cardiomyopathy due to drug and external agent), I42.8 (Other cardiomyopathies), I42.9 (Cardiomyopathy, unspecified), I43 (Cardiomyopathy in diseases classified elsewhere), I45.6 (Pre-excitation syndrome), I45.9 (Conduction disorder, unspecified), I50 (Heart failure), I70,

	(Atherosclerosis) I73.1 (Thromboangiitis obliterans [Buerger's disease]), I79.2, T82.1 (Mechanical complication of cardiac electronic device), Z45.0 (Encounter for adjustment and management of cardiac device), Z95.0 (Presence of cardiac pacemaker), Z95.8 (Presence of other cardiac and vascular implants and grafts), Z95.9 (Presence of cardiac and vascular implant and graft, unspecified)
Hypertension	I11.0 (Hypertensive heart disease with heart failure), I13.0 (Hypertensive heart and chronic kidney disease with heart failure and stage 1 through stage 4 chronic kidney disease, or unspecified chronic kidney disease), I13.2 (Hypertensive heart and chronic kidney disease with heart failure and with stage 5 chronic kidney disease, or end stage renal disease), I10 (Essential (primary) hypertension), I11 (Hypertensive heart disease), I12 (Hypertensive chronic kidney disease), I13 (Hypertensive heart and chronic kidney disease), I15 (Secondary hypertension)
Cardiac Valvular Disease	I05 (Rheumatic mitral valve diseases), I06 (Rheumatic aortic valve diseases), I07(Rheumatic tricuspid valve diseases), I08 (Multiple valve diseases), I09.1, (Rheumatic diseases of endocardium, valve unspecified), I34 (Nonrheumatic mitral valve disorders), I35 (Nonrheumatic aortic valve disorders), I36 (Nonrheumatic tricuspid valve disorders), I37 (Nonrheumatic pulmonary valve disorders), I38 (Endocarditis, valve unspecified), I39 (Endocarditis and heart valve disorders in diseases classified elsewhere), Q23.0 (Congenital stenosis of aortic valve), Q23.1, (Congenital insufficiency of aortic valve), Z95.2 (Presence of prosthetic heart valve), Z95.3 (Presence of xenogenic heart valve), Z95.4 (Presence of other heart-valve replacement), I71 (Aortic aneurysm and dissection), Q23.2 (Congenital mitral stenosis), Q23.3 (Congenital mitral insufficiency),
Cardiac Arrhythmias	I47 (Paroxysmal tachycardia), I48 (Atrial fibrillation and flutter), I49 (Other cardiac arrhythmias), I44.1 (Atrioventricular block, second degree), I44.2 (Atrioventricular block, complete), I44.3 (Other and unspecified atrioventricular block), R00.0 (Tachycardia, unspecified), R00.1 (Bradycardia, unspecified), R00.8 (Other abnormalities of heart beat),

Cardiac Peripheral Vascular Disease	I73.8 (Other specified peripheral vascular diseases), I73.9 (Peripheral vascular disease, unspecified), K55.1 (Chronic vascular disorders of intestine), K55.8 (Other vascular disorders of intestine), K55.9 (Vascular disorder of intestine, unspecified), I77.1 (Stricture of artery), I79.0 (Aneurysm of aorta in diseases classified elsewhere)
CerebrovascularDisease	G45 (Transient cerebral ischemic attacks and related syndromes), G46 (Vascular syndromes of brain in cerebrovascular diseases), H34.0 (Transient retinal artery occlusion), I60 (Nontraumatic subarachnoid hemorrhage), I61 (Nontraumatic intracerebral hemorrhage), I62 (Other and unspecified nontraumatic intracranial hemorrhage), I63 (Cerebral infarction), I64, I65 (Occlusion and stenosis of precerebral arteries, not resulting in cerebral infarction), I66 (Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction), I67 (Other cerebrovascular diseases), I68 (Cerebrovascular disorders in diseases classified elsewhere), I69 (Sequelae of cerebrovascular disease)
Coagulopathy	D65 (Disseminated intravascular coagulation [defibrination syndrome]), D66 (Hereditary factor VIII deficiency), D67 (Hereditary factor IX deficiency), D68 (Other coagulation defects), D69.1 (Qualitative platelet defects), D69.3 (Immune thrombocytopenic purpura), D69.4 (Other primary thrombocytopenia), D69.5 (Secondary thrombocytopenia), D69.6 (Thrombocytopenia, unspecified)
Anemia	D50.8 (Other iron deficiency anemias), D50.9 (Iron deficiency anemia, unspecified), D51 (Vitamin B12 deficiency anemia), D52 (Folate deficiency anemia), D53 (Other nutritional anemias)
Diabetes	E10.0, E10.1, E10.2, E10.3, E10.4, E10.5, E10.6, E10.7, E10.8, E10.9, E11.0, E11.1, E11.2, E11.3, E11.4, E11.5, E11.6, E11.7, E11.8, E11.9, E12.0, E12.1, E12.2, E12.3, E12.4, E12.5, E12.6, E12.7, E12.8, E12.9, E13.0, E13.1, E13.2, E13.3, E13.4, E13.5, E13.6, E13.7, E13.8, E13.9, E14.0, E14.1, E14.2, E14.3, E14.4, E14.5, E14.6, E14.7, E14.8, E14.9
Drug Abuse	F11, F12, F13, F14, F15, F16, F18, F19, Z71.5, Z72.2

HIV/AIDS	B20 (Human immunodeficiency virus [HIV] disease)
Hypothyroidism	E00 (Congenital iodine-deficiency syndrome), E01 (Iodine-deficiency related thyroid disorders and allied conditions), E02 (Subclinical iodine-deficiency hypothyroidism), E03 (Other hypothyroidism), E89.0 (Postprocedural hypothyroidism)
Liver Disease	B18, I85, I86.4, I98.2, K70, K71.1, K71.3, K71.4, K71.5, K71.7, K72, K73, K74, K76.0, K76.2, K76.3, K76.4, K76.5, K76.6, K76.7, K76.8, K76.9, Z94.4
Chronic Neurological Conditions	F01.5 (Vascular dementia), F03.9 (Unspecified dementia), G10 (Huntingtons disease), G11 (hereditary ataxia), G12 (spinal muscular atrophy and related syndromes), G13 (systemic atrophies primarily affecting central nervous system in diseases classified elsewhere), G20 (Parkinsons disease), G21 (Secondary parkinsonism), G22, G25.4 (Drug-induced chorea), G25.5 (other chorea), G30 (Alzheimers disease), G31.2 (degeneration of nervous system due to alcohol), G31.8 (other specified degenerative diseases of nervous system), G31.9 (Degenerative disease of nervous system, unspecified), G32 (other degenerative disorders of nervous system in diseases classified elsewhere), G35 (Multiple Sclerosis), G36 (Other acute disseminated demyelination), G37 (Other demyelinating diseases of central nervous system), G40 (Epilepsy and recurrent seizures), G41, R47.0 (Dysphasia and aphasia), R56 (Convulsions, not elsewhere classified)
Acute Neurological Conditions (captured on day of index hospital admission only)	G93.1 (Anoxic brain damage, not elsewhere classified), G93.4 (other and unspecified encephalopathy)
Obesity	E66, Z68.3, Z68.4, E66.01, E66.2, Z68.4
Paralysis	G04.1 (Tropical spastic paraplegia), G11.4 (Hereditary spastic paraplegia), G80.1 (Spastic diplegic cerebral palsy), G80.2 (Spastic hemiplegic cerebral palsy), G81 (Hemiplegia and hemiparesis), G82 (Paraplegia (paraparesis) and quadriplegia (quadriparesis)), G83.0 (Diplegia of upper limbs), G83.1 (Monoplegia of lower limb), G83.2 (Monoplegia of upper limb), G83.3 (Monoplegia, unspecified), G83.4 (Cauda equina

	syndrome), G83.9 (Paralytic syndrome, unspecified)
Chronic Psychoses	F20 (Schizophrenia), F22(Delusional disorders), F23 (Brief psychotic disorder), F24 (Shared psychotic disorder), F25 (Schizoaffective disorders), F28 (Other psychotic disorder not due to a substance or known physiological condition), F30.2 (Manic episode, severe with psychotic symptoms), F31.2 (Bipolar disorder, current episode manic severe with psychotic features), F31.5 (Bipolar disorder, current episode depressed, severe, with psychotic features)
Acute Psychoses (captured on day of index hospital admission only)	F29 (Unspecified psychosis not due to a substance or known physiological condition)
Pulmonary Disease[1]	E84.0, E84.11, E84.19, E84.9, I26, I27, I27.8, I27.9, I28.0, I28.8, I28.9, J40, J41, J42, J43, J44, J45, J45.4, J45.5, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67, J68.4, J70.1, J70.3, J84.1, J84.9
Rheumatoid Arthritis, Collagen Vascular Disease	L94.0, L94.1, L94.3, M05, M06, M08, M12.0, M12.3, M30, M31.0, M31.1, M31.2, M31.3, M32, M33, M34, M35, M45, M46.1, M46.8, M46.9
Smoking	F17 (Nicotine dependence), I73.1 (Thromboangiitis obliterans [Buerger's disease]), J41 (simple and mucopurulent chronic bronchitis), J42 (Unspecified chronic bronchitis), J43 (Emphysema), J44 (Other chronic obstructive pulmonary disease), T65.2 (Toxic effect of tobacco and nicotine), Z71.6 (Tobacco abuse counseling), Z72.0 (Tobacco use)
Solid Organ Transplantation, excluding kidney	Z94.1 (Heart transplant status), Z94.2 (Lung transplant status), Z94.3 (Heart and lungs transplant status), Z94.4 (Liver transplant status), Z94.83 (Pancreas transplant status)

[1]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S3.2 In-hospital medications and high acuity treatments administered to patients discharged alive from the hospital with and without ESRD (N=5,260)

Medication/Treatment		Non-ESRD (N=5,260)	ESRD (N=374)
Remdesivir		1295 (26.5)	78 (20.9)
Dexamethasone		2534 (51.9)	166 (44.4)
Oral Blood Thinner		710 (14.5)	68 (18.2)
Monoclonal Antibodies		66 (1.4)	10 (2.7)
Bamlanivimab		24 (0.5)	6 (1.6)
Casirivimab		9 (0.2)	2 (0.5)
Tocilizumab		33 (0.7)	2 (0.5)
Mechanical Ventilation		1064 (21.8)	93 (24.9)
ECMO		10 (0.2)	1 (0.3)
ICU Admission		937 (19.2)	84 (22.5)

Abbreviations: ICU=Intensive Care Unit, ECMO=extracorporeal membrane oxygenation

Supplemental Table S3.3 Univariate and multivariate Cox proportional hazards regression analyses of risk factors associated with readmission within 30 days post-discharge among patients without ESRD (N=4,886)

Variable		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
		Univariate			**Multivariate[1]**		
Age (per 10 years increase)		1.01	0.96, 1.06	0.7681	0.91	0.86, 0.97	0.0018
Sex	Female (referent)						
	Male	0.87	0.72, 1.05	0.1391	0.87	0.72, 1.05	0.1481
Race/ethnicity	White (referent)						
	Asian	1.13	0.82, 1.55	0.4619	1.30	0.94, 1.81	0.1108
	Black	1.32	0.94, 1.86	0.1055	1.27	0.9, 1.79	0.1714
	Hispanic	0.91	0.72, 1.14	0.3945	1.00	0.79, 1.28	0.9694
	Other/Unknown	0.76	0.52, 1.12	0.1665	0.87	0.59, 1.28	0.4804
Area Deprivation Index[2]	1	0.54	0.32, 0.89	0.0168			
	2	0.65	0.4, 1.07	0.0882			
	3	0.88	0.55, 1.39	0.5735			
	4	0.83	0.53, 1.3	0.4145			
	5	0.61	0.39, 0.96	0.0331			
	6	0.86	0.55, 1.34	0.5103			
	7	0.67	0.41, 1.08	0.0995			
	8	0.92	0.57, 1.47	0.7200			
	9	1.00	0.63, 1.61	0.9893			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		2.60	2.13, 3.16	<.0001	2.20	1.79, 2.7	<.0001
Major Cardiac Disease		2.08	1.68, 2.58	<.0001	1.64	1.29, 2.09	<.0001
Valvular Cardiac Disease		1.75	1.43, 2.16	<.0001			
Cardiac Arrhythmias		1.39	1.14, 1.68	0.0009			

Variable		Univariate			Multivariate[1]		
		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
Peripheral Vascular Disease		1.39	1.07, 1.81	0.0130	1.03	0.78, 1.35	0.8397
Coagulopathy		1.97	1.62, 2.39	<.0001	1.42	1.16, 1.75	0.0009
Anemia		2.23	1.81, 2.75	<.0001	1.63	1.3, 2.03	<.0001
Diabetes		1.08	0.89, 1.3	0.4575	0.95	0.78, 1.16	0.5980
HIV/AIDS		1.58	0.84, 2.96	0.1520			
Hypertension		1.30	1.07, 1.59	0.0090			
Hyperthyroidism		1.07	0.82, 1.4	0.6202			
Chronic Neurological Conditions		1.30	1.04, 1.61	0.0209			
Acute Neurological Conditions		0.90	0.66, 1.22	0.4874			
Obesity		1.00	0.83, 1.22	0.9674			
Paralysis		1.24	0.83, 1.86	0.2939			
Chronic Psychoses		0.94	0.59, 1.48	0.7828			
Acute Psychoses		0.53	0.17, 1.65	0.2711			
Pulmonary Disease[4]		1.57	1.3, 1.89	<.0001			
Rheumatoid Arthritis/CVD		1.42	1.05, 1.94	0.0251			
Smoking		1.42	1.15, 1.76	0.0011	1.25	1, 1.55	0.0481
Solid Organ Transplantation, excluding Kidney		1.45	0.94, 2.22	0.0916			
Liver Disease		1.59	1.29, 1.96	<.0001			
Cerebrovascular Disease		1.38	1.1, 1.72	0.0053			
Drug Abuse		1.17	0.88, 1.54	0.2725			

Abbreviations: HR=hazard ratio, CVD=collagen vascular disease
[1]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]For comorbid conditions the absence of the condition is the referent
[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S3.4 Univariate and multivariate Cox proportional hazards regression analyses of risk factors associated with readmission within 30 days post-discharge among patients with ESRD (N=374)

Variable		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
		Univariate			**Multivariate[1]**		
Age (per 10 years increase)		0.95	0.82, 1.11	0.5411	0.99	0.83, 1.17	0.8758
Sex	Female (referent)						
	Male	0.82	0.5, 1.33	0.4139	0.78	0.48, 1.27	0.3161
Race/ethnicity	White (referent)						
	Asian	0.60	0.18, 1.95	0.3962	0.87	0.25, 3	0.8301
	Black	1.42	0.6, 3.37	0.4279	1.66	0.68, 4.07	0.2665
	Hispanic	0.97	0.47, 2.01	0.9427	1.16	0.52, 2.63	0.7150
	Other/Unknown	0.44	0.1, 2.04	0.2945	0.49	0.1, 2.33	0.3711
Area Deprivation Index[2]	1	0.42	0.09, 2.09	0.2901			
	2	0.76	0.24, 2.34	0.6267			
	3	0.30	0.06, 1.51	0.1447			
	4	0.10	0.01, 0.81	0.0315			
	5	0.52	0.18, 1.49	0.2236			
	6	0.97	0.38, 2.5	0.9529			
	7	0.58	0.21, 1.6	0.2913			
	8	0.31	0.08, 1.26	0.1015			
	9	0.97	0.35, 2.74	0.9606			
	10 (referent)						
Comorbid Conditions[3]							
Cancer		1.28	0.68, 2.39	0.4455	1.13	0.58, 2.21	0.7238
Major Cardiac Disease		1.94	0.48, 7.93	0.3556	1.73	0.41, 7.35	0.4580

Variable		Univariate			Multivariate[1]		
		HR	95% CI	p Value	Adjusted HR	95% CI	p Value
Valvular Cardiac Disease		1.32	0.81, 2.15	0.2664			
Cardiac Arrhythmias		1.23	0.68, 2.22	0.4920			
Peripheral Vascular Disease		1.89	1.16, 3.07	0.0106	2.22	1.3, 3.79	0.0034
Coagulopathy		0.97	0.59, 1.6	0.9104	0.90	0.54, 1.5	0.6972
Anemia		0.83	0.5, 1.37	0.4633	0.68	0.4, 1.16	0.1543
Diabetes		0.59	0.35, 0.98	0.0414	0.51	0.29, 0.89	0.0170
HIV/AIDS		0.00		0.9834			
Hypertension		2.28	0.32, 16.43	0.4135			
Hyperthyroidism		1.32	0.76, 2.29	0.3264			
Chronic Neurological Conditions		0.89	0.51, 1.57	0.6867			
Acute Neurological Conditions		1.29	0.73, 2.26	0.3836			
Obesity		1.34	0.82, 2.17	0.2432			
Paralysis		1.35	0.58, 3.12	0.4848			
Chronic Psychoses		1.05	0.26, 4.3	0.9423			
Acute Psychoses		1.83	0.25, 13.18	0.5493			
Pulmonary Disease[4]		1.74	1.06, 2.85	0.0291			
Rheumatoid Arthritis/CVD		1.42	0.74, 2.72	0.2871			
Smoking		1.40	0.83, 2.36	0.2022	1.21	0.68, 2.15	0.5102
Solid Organ Transplantation, excluding Kidney		0.63	0.23, 1.74	0.3735			
Liver Disease		1.27	0.76, 2.11	0.3561			
Cerebrovascular Disease		1.34	0.82, 2.2	0.2490			
Drug Abuse		1.14	0.52, 2.5	0.7438			

Abbreviations: HR=hazard ratio, CVD=collagen vascular disease

[1]The multivariate model includes the demographic variables age, sex, and race/ethnicity and factors significant at the p= 0.05 level in two-sided tests in models for patients with or without ESRD
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]For comorbid conditions the absence of the condition is the referent
[4]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Figure S3.1 Forest plot showing the multivariate risk factors for readmission within 30 days post-hospital discharge among patients with and without ESRD (N=5,260)

Hazard ratio with 95% confidence interval
(log scale)
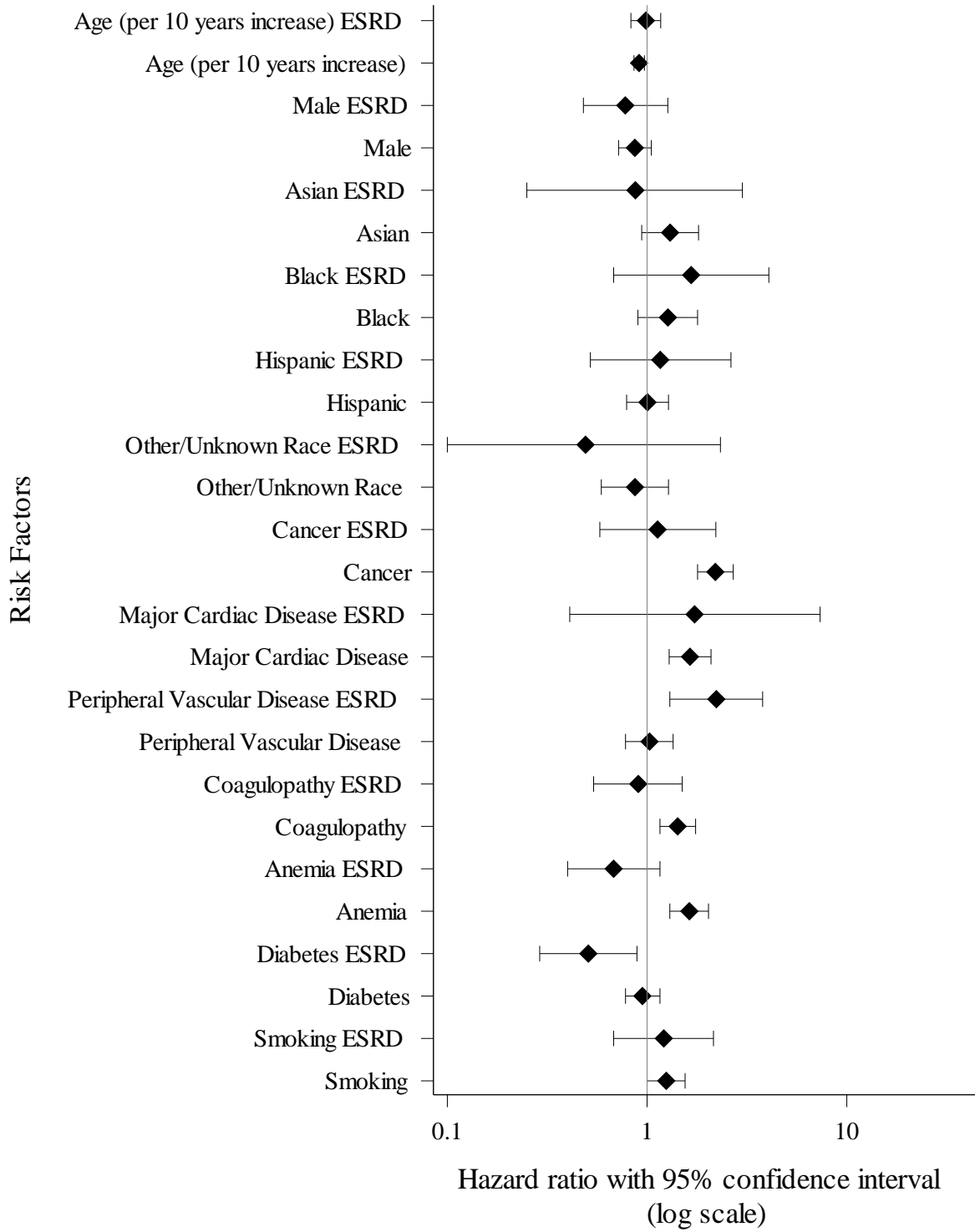
Supplemental Table S3.5 Demographic and clinical characteristics of patients by alive or expired status 30 days post-discharge (N=5,260)

Variable		Alive (N=5,047)	Expired (N=213)
Sex	Male	2814 (55.8)	127 (59.6)
Age (years)[1]		58 (44, 71)	60.5 (49, 70)
Age (%)	18-39	1007 (20)	7 (3.3)
	40-49	691 (13.7)	6 (2.8)
	50-59	1006 (19.9)	24 (11.3)
	60-69	1015 (20.1)	41 (19.2)
	70-79	713 (14.1)	45 (21.1)
	80+	615 (12.2)	90 (42.3)
Race/Ethnicity	White	1355 (26.8)	69 (32.4)
	Asian	513 (10.2)	40 (18.8)
	Other/Unknown	474 (9.4)	19 (8.9)
	Hispanic	2293 (45.4)	75 (35.2)
	Black	412 (8.2)	10 (4.7)
Area Deprivation Index[2]	Missing	812 (16.1)	28 (13.1)
	1	412 (8.2)	19 (8.9)
	2	397 (7.9)	15 (7)
	3	381 (7.5)	18 (8.5)
	4	489 (9.7)	23 (10.8)
	5	605 (12)	33 (15.5)
	6	502 (9.9)	25 (11.7)
	7	457 (9.1)	13 (6.1)
	8	362 (7.2)	9 (4.2)
	9	326 (6.5)	15 (7)
	10	304 (6)	15 (7)
Comorbid Condition			
Cancer		840 (16.6)	79 (37.1)
Major Cardiac Disease		3034 (60.1)	189 (88.7)
Valvular Cardiac Disease		1034 (20.5)	84 (39.4)
Cardiac Arrhythmias		2760 (54.7)	159 (74.6)
Cardiac PVD		656 (13)	48 (22.5)

Variable		Alive (N=5,047)	Expired (N=213)
Cerebrovascular		918 (18.2)	77 (36.2)
Coagulopathy		1168 (23.1)	91 (42.7)
Deficiency Anemia		835 (16.5)	48 (22.5)
Diabetes		2063 (40.9)	106 (49.8)
Drug Abuse		578 (11.5)	14 (6.6)
HIV/AIDS		78 (1.5)	1 (0.5)
Hypertension		3107 (61.6)	184 (86.4)
Hyperthyroidism		702 (13.9)	45 (21.1)
Liver Disease		1036 (20.5)	49 (23)
Chronic Neurological Conditions		967 (19.2)	96 (45.1)
Acute Neurological Conditions		533 (10.6)	97 (45.5)
Obesity		1858 (36.8)	52 (24.4)
Paralysis		237 (4.7)	20 (9.4)
Chronic Psychoses		227 (4.5)	8 (3.8)
Acute Psychoses		64 (1.3)	1 (0.5)
Pulmonary Disease[3]		1760 (34.9)	91 (42.7)
Rheumatoid Arthritis/CVD		397 (7.9)	21 (9.9)
Smoking		1073 (21.3)	53 (24.9)
Solid Organ Transplantation, excluding Kidney		211 (4.2)	1 (0.5)
ESRD		350 (6.9)	24 (11.3)

Abbreviations: ICU=intensive care unit, CVD=Collagen Vascular Disease, ECMO=extracorporeal membrane oxygenation
[1]Data are expressed as medians (interquartile ranges)
[2]ADIs are calculated in deciles with an ADI of 1, 10 signifying a neighborhood that is least, most socioeconomically disadvantaged, respectively
[3]Pulmonary disease includes asthma and chronic obstructive pulmonary disease

Supplemental Table S3.6 In-hospital medications and high acuity treatments administered to patients, by alive or expired status 30 days post-discharge (N=5,260)

Medication/Treatment		Alive (N=5,047)	Expired (N=213)
Remdesivir		1318 (26.1)	55 (25.8)
Dexamethasone		2564 (50.8)	136 (63.8)
Oral Blood Thinner		726 (14.4)	52 (24.4)
Monoclonal Antibodies		71 (1.4)	5 (2.3)
Bamlanivimab		27 (0.5)	3 (1.4)
Casirivimab		11 (100.0)	0 (0.0)
Tocilizumab		33 (0.7)	2 (0.9)
Mechanical Ventilation		1113 (22.1)	44 (20.7)
ECMO		8 (0.2)	3 (1.4)
ICU Admission		953 (18.9)	68 (31.9)

Abbreviations: ICU=Intensive Care Unit, ECMO=extracorporeal membrane oxygenation