Incidence and Risk Factors for Acute Kidney Injury and its effect on Mortality in Patients Hospitalized from Covid-19

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Abstract

Objective

To determine the incidence of and risk-factors for development of acute kidney injury (AKI) and investigate the association between AKI and mortality in patients hospitalized with Covid-19.

Patients and Methods

This retrospective case series includes the first 370 patients consecutively hospitalized with confirmed Covid-19 illness between March 10, 2020 and May 13, 2020, at a 242-bed teaching hospital. To determine independent association between demographic factors, comorbidities and AKI incidence, multivariable-logistic regression models were used to estimate odds ratios adjusted for clinical covariates.

Results

Median age of patients was 71 (59–82) years and 44.3% were female. Patients with AKI were significantly older with a higher comorbidity-burden and mortality-rate (58.1% vs 19.6%, p<.001) when compared to those without AKI. Increasing age, chronic kidney disease, hyperlipidemia and being of African-American descent showed higher odds of AKI. Patients with AKI had significantly higher odds of mortality when compared to patients without AKI, and this effect was proportional to the stage of AKI. Increasing age and acute respiratory distress syndrome also revealed higher adjusted odds of mortality.
**Conclusion**

AKI is a common complication among hospitalized Covid-19 patients. We found significantly higher odds of AKI with increasing age, among hyperlipidemics and patients with chronic kidney disease and among African-Americans. We demonstrate an independent association between AKI and mortality with increasingly higher odds of mortality from progressively worsening renal failure in hospitalized Covid-19 patients.
**Abbreviations used in the manuscript:**

ACE-2 – Angiotensin converting enzyme-2

AKI – Acute kidney injury

ARDS – Acute respiratory distress syndrome

BMI – Body mass index

CKD – Chronic kidney disease

COPD – Chronic obstructive pulmonary disease

Covid-19 – Coronavirus disease 2019

SARS-CoV-2 – Severe acute respiratory syndrome coronavirus-2
Introduction:

In December 2019, a cluster of patients with pneumonia was reported in Wuhan, Hubei Province, China which was later identified to be caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).\textsuperscript{1} The illness caused by SARS-CoV-2, Coronavirus disease 2019 (Covid-19) was declared as a pandemic by the World Health Organization (WHO) on March 11, 2020. The illness mainly manifests as fever, cough, myalgia or fatigue, sputum production, headache, and diarrhea.\textsuperscript{2} Covid-19 illness severity can run the spectrum from asymptomatic infection, self-limited flu-like illness, and acute pneumonia, to sepsis leading to life-threatening complications including acute respiratory distress syndrome, acute cardiac injury, acute kidney injury and septic shock.\textsuperscript{3,4}

The reported incidence of acute kidney injury (AKI) in Covid-19 has ranged from 0.5% to 27% among hospitalized patients.\textsuperscript{2,3,5-7} Reports on incidence of AKI in hospitalized patients from western countries is lacking and much needed. For this study, we aimed to determine the incidence of AKI in patients hospitalized with Covid-19 and assess demographic factors and comorbidities that portend an increased risk of AKI in these patients. We also evaluated association between AKI and mortality in these patients.

Methods:

Data source

This retrospective case series includes the first 370 patients consecutively hospitalized with confirmed Covid-19 illness between March 10, 2020 and May 13, 2020, at a 242-bed teaching community hospital in the New York City metropolitan area. The hospital has a 12-bed
Intensive Care Unit (ICU) and serves approximately 250,000 people in the southern Westchester County, New York. Cases were confirmed through positive result for SARS-CoV2 virus by reverse-transcriptase-polymerase-chain-reaction testing of nasopharyngeal swab specimen. Data were manually abstracted from electronic health records by the authors, and included demographics, comorbid conditions and outcomes (AKI, acute respiratory distress syndrome (ARDS), mortality or discharge). Three authors (AN, AN and SP) independently reviewed the data for accuracy. Patient outcomes were followed up until June 10, 2020.

**Definition of patient characteristics**

Comorbidities derived from the patients or nursing home transfer forms were abstracted from physician documentation on the electronic health records. End-stage renal disease patients were all patients with renal disease on chronic dialysis. Cardiac disease was defined as chronic heart conditions including but not limited to coronary artery disease, previous myocardial infarction, cardiac arrhythmias, congestive heart failure, presence of pacemaker or defibrillator device and previous coronary artery bypass grafting or percutaneous coronary intervention. Body mass index (BMI) was used to classify patients into normal weight (BMI 18.5 to 24.9 kilogram/meter$^2$), overweight (BMI 25 to 29.9 kg/m$^2$), obese (BMI $\geq$30 kg/m$^2$) and malnourished (BMI $<$18.5 kg/m$^2$) categories, based on the classification by the World Health Organization. Primary Insurance coverage was classified as Medicare, Medicaid, Private or others (self-pay/no insurance). Race was categorized into one of the four groups: Caucasian, African-American, Hispanic and Others.
Acute kidney injury was identified as defined by the criteria from the Kidney Disease Improving Global Outcomes (KDIGO) and the International Society of Nephrology.\(^9\) We did not have access to preadmission baseline creatinine values for majority of patients. Therefore, we considered the lowest creatinine level recorded during admission as the baseline, and then retrospectively compared this “baseline” to the highest creatinine recorded.\(^10\) We did not include urine output in our determination of AKI, given the heterogeneity of urine output recordings and the high degree of missing data. Using the KDIGO criteria, AKI was further characterized into stages on the basis of maximal difference between the baseline creatinine and the peak creatinine during the hospital stay. AKI was staged as follows: 1) Stage 1 – Increase in serum creatinine to 1.5 to 1.9 times baseline, or increase in serum creatinine by ≥0.3 mg/dL (≥26.5 micromol/L), 2) Stage 2 – Increase in serum creatinine to 2.0 to 2.9 times baseline, 3) Stage 3 – Increase in serum creatinine to 3.0 times baseline, or increase in serum creatinine to ≥4.0 mg/dL. Acute respiratory distress syndrome (ARDS) was defined as per the Berlin criteria.\(^11\)

We could not determine AKI status for patients with only one creatinine value recorded during the hospital stay, and thus excluded these patients from analysis (n=10). We excluded patients with end stage renal disease as well (n=28). Patients who did not yet have a definite outcome of mortality or discharge, i.e. patients who were still being treated at the time of writing were excluded as well (n=5). After said exclusions, final analysis included 327 patients.

**Outcome measures and statistical analysis**

We computed median, inter-quartile range, frequency, and percentages as our descriptive variables. Differences in median and percentage were assessed using the Mann-Whitney and
chi-squared test respectively. We calculated odds ratios for outcomes, AKI and mortality, by univariable and age-sex adjusted models. To determine independent association between demographic factors, comorbidities and AKI incidence, multivariable-logistic regression models were used to estimate odds ratios (OR) adjusted for clinical covariates. Demographic factors (age, sex, race) and major comorbidities (hypertension, diabetes, cardiac disease) were considered the six essential covariates and always included for adjustment in the multivariable model. In addition, the covariates that showed significant odds in the age-sex adjusted model, were included in the multivariable models. ARDS was used as an additional covariate to calculate OR for mortality. Two-sided $P<.05$ was considered statistically significant. Data was analyzed using Stata version-13.0 (Stata Corp, College Station, TX).

**Statement of ethics**

The study was carried out in accordance with the Declaration of Helsinki, and was approved by the departmental research review committee with a waiver of informed consent due to its retrospective design [Approval number 20.5.01].

**Role of the Funding Source**

The study was not funded.

**Results:**

Median age of patients was 71 (inter-quartile range 59–82) years and 44.3% were female. Most commonly observed comorbidities were hypertension (63.9%), diabetes (42.5%), hyperlipidemia (34.9%), obesity (34.6%) and cardiac diseases (29.9%) (Table 1). The overall
mortality rate was 40.7%. AKI was observed in 179 (54.7%) of patients. 69 (21.1%) patients had Stage-1 AKI, 42 (12.8%) had Stage-2 AKI and 68 (20.8%) had Stage-3 AKI. AKI was present on admission in 137/179 (76.5%) patients, and another 26/179 (14.5%) of patients developed AKI within 48 hours of admission. 20 patients received urgent dialysis for Stage-3 AKI. Patients with AKI were significantly older, less likely to be Hispanic, and had a higher prevalence of major comorbidities (hypertension, diabetes, hyperlipidemia and CKD) when compared to patients without AKI. Mortality was significantly higher in patients with AKI when compared to patients without AKI (58.1% vs 19.6%, p <.001 Table 1).

On univariable-analysis, age, hypertension, diabetes, hyperlipidemia and CKD had higher odds of AKI in Covid-19 patients (Supplemental Table 1). In the age-sex adjusted model, race, diabetes, hyperlipidemia and CKD showed higher odds of AKI. Covariates in the multivariable model for AKI thus included the six essential covariates identified in the methodology along with race, hyperlipidemia and CKD. In the multivariable model, increasing age [OR 1.03 for every 1-year increase in age, 95% Confidence Interval (CI) (1.01-1.05), p=.007], African-American race, presence of CKD and hyperlipidemia showed higher odds of AKI.

On univariable analysis AKI, ARDS, increasing age, Insurance and nursing home status and several comorbidities showed higher odds of mortality (Supplemental Table 2). Age-sex adjusted analysis demonstrated AKI, ARDS and BMI-class with significant impact on odds of mortality. Thus, these covariates were included in addition to the six pre-identified essential covariates in the multivariable model for mortality. On multivariable analysis, patients with AKI had significantly higher odds of mortality when compared to patients without AKI, and this effect was proportional to the Stage of AKI (Table 3 and Figure 1). In addition to AKI, advancing
age and ARDS were the only other covariates to significantly impact in-hospital mortality (Table 3).

Discussion:

Although Covid-19 manifests primarily in the lungs, it is increasingly being recognized for involvement of the kidney, gastrointestinal-tract, heart and coagulation system. Even as scientific data linking Covid-19 to kidney disease is expanding, there is a dearth of clinical data on the incidence of AKI in Covid-19. We present one of the first reports assessing AKI among hospitalized Covid-19 patients in the western hemisphere. This is also one of the first study proving the association of AKI to mortality in Covid-19. We saw increasing odds of mortality with progressively severe renal failure in these patients. This effect on mortality persisted despite adjusting for demographics, comorbidities and acute lung injury (ARDS) which has been shown to be the primary pathway for serious illness and mortality.\textsuperscript{5, 12} We also saw higher adjusted odds of mortality with increasing age and in patients with ARDS (Figure 1). These findings are similar to the experience from China, although our data is based on multi-variate analysis and is thus more robust.\textsuperscript{5, 13} Multi-variate analysis by Chu et al. from the 2002-2003 SARS-Corona virus epidemic, identified almost identical risk factors for mortality as our study.\textsuperscript{14} In their study the authors described increasing odds of mortality with age, AKI and ARDS similar to our analysis, supporting the validity of our findings.

There are several mechanisms by which Covid-19 could impact the kidney. One of the mechanisms involves the cytokine release syndrome or the “cytokine storm” from sepsis in response to the SARS-CoV-2.\textsuperscript{2} Cytokine release syndrome has been reported in Covid-19 and
could cause AKI by leading to intrarenal inflammation, increased vascular permeability, volume
depletion and cardiomyopathy, which can lead to cardiorenal syndrome. Studies have reported
similar expression of ACE-2 among old and young subjects. There is however, a tendency for a
stronger immune response, potentially leading to cytokine storm related injury in the lungs of
older individuals. Increased mortality with increasing age could thus be a reflection of a more
robust rise in cytokines in the elderly. Organ cross-talk in Covid-19 could be another mechanism
for AKI. Rhabdomyolysis leading to acute tubular necrosis, alveolar damage leading to renal
medullary hypoxia and acute tubular necrosis secondary to abdominal compartment syndrome
from high peak airway-pressure and intra-abdominal hypertension, are some of the possible
scenarios. Systemic effects of severe sepsis such as, endothelial damage leading to third-space
fluid loss and hypotension as well as endotoxins, could be another pathway for AKI in Covid-19.

In addition to renal dysfunction as a result of immune-dysregulation, emerging evidence
suggests the possibility of a direct cytopathic effect of SARS-CoV-2 on the kidney. Although
SARS-CoV-2 enters the human body mostly through lungs (and occasionally gastrointestinal
tract), ribo-nucleic acid (RNA) viremia has been reported during infection (15% of cases), thus
allowing the virus to reach all organs in the body, including the kidneys. In addition,
Angiotensin-converting enzyme-2 (ACE-2), which has been described as the most likely
“receptor” for viral entry into human cells (along with serine proteases), is heavily expressed in
tissues outside the lungs. In fact, studies report higher expression of ACE-2 in intestine, testis,
heart and kidneys, than in the lungs. Indeed, in a recent report of postmortem analysis of
26 Covid-19 patients, 7 patients were found to have coronavirus particles with distinctive spikes
in the renal tubular epithelium and podocytes. In addition to viral particles, acute tubular

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necrosis, lymphocyte infiltration and enhanced CD68+ macrophages have been described in the interstitium with membrane-attack-complex (complement C5b-9) deposition on tubules.\textsuperscript{6}

The incidence of AKI in our study was much higher than previously reported. This could partly be due to a difference in frequency of testing creatinine, as detection of AKI is mainly based on acute changes in serum creatinine and the frequency of serum creatinine tests has a substantial impact on detection rate.\textsuperscript{5} Xu et al, demonstrated higher expression of ACE-2 in kidneys of donors from western countries compared to Asian population, which could in part explain the higher rates of AKI in our study.\textsuperscript{17} We used serum creatinine values during the entire hospitalization to calculate the difference between baseline and peak creatinine, as kidney dysfunction in Covid-19 might not be readily evident at admission and progress during hospitalization.\textsuperscript{13} This may be due to the fact that the cytokine storm can occur a few days after illness onset, thus resulting in AKI days after hospitalization.\textsuperscript{19} Indeed in our study, 35/179 (19.6\%) of the AKI diagnoses were made past the traditionally used limit of the initial 48 hours of hospital stay. Using the entire hospital stay to calculate AKI instead of the first 48-72 hours, may be another reason for a seemingly higher AKI incidence in our study.

We saw higher adjusted odds of AKI in older individuals, in African-Americans, in individuals with hyperlipidemia and history of CKD. Older age has consistently been reported as a risk factor for worse outcome including mortality and AKI.\textsuperscript{5,12} Our observation of higher odds of AKI in CKD and higher prevalence of CKD in patients with AKI is not surprising, as CKD is a well-known risk-factor for AKI.\textsuperscript{20} We also found higher odds of AKI in patients with hyperlipidemia. Hypercholesterolemia and hypertriglyceridemia are known to be independent predictors of CKD.\textsuperscript{21,22} In addition, increased total cholesterol and low-density lipoprotein measured at
baseline have been reported as independent risk factors for ESRD.\textsuperscript{21, 22} Despite the known associations of hyperlipidemia and kidney disease, the mechanisms behind increasing AKI with hyperlipidemia are not completely understood and should be investigated. Higher AKI among African-Americans is not surprising as racial and ethnic minorities are increasingly being recognized as having a more severe clinical course and worse outcomes with Covid-19.\textsuperscript{23}

Overall, AKI had a significant impact on the outcome of death among patients hospitalized with Covid-19. Patients who developed AKI had a much higher mortality rate (58.1\% vs 19.6\%, \(p <.001\)) when compared to those without and our analysis revealed significantly higher odds of mortality in Covid-19 patients with AKI.

**Conclusion:**

In addition to lungs, kidneys are particularly prone to disruption by Covid-19. We present one of the first reports describing the incidence of AKI and potential risk factors for development of AKI in patients with Covid-19. We found significantly higher odds of AKI with increasing age, among African-Americans, hyperlipidemics and patients with chronic kidney disease. We demonstrate an independent association between AKI and mortality with increasingly higher odds of mortality from progressively worsening renal failure in hospitalized Covid-19 patients.

**Strengths and Limitations:**

This is a single center study, retrospective study. Previous creatinine values were available in only 172/327 (52.6\%) of patients and thus a decision to use the lowest creatinine in the hospital stay as the patients’ baseline creatinine was made. When previous creatinine values were available, they were comparable to and not significantly different from the lowest creatinine
values during hospital stay ($p=.5$). We could not include urine output in our determination of AKI, given the heterogeneity of urine output recordings and the high degree of missing data. The incidence of rhabdomyolysis was not recorded for most patients in the study. However, the authors believe even if some of the AKI were secondary to rhabdomyolysis from Covid-19 infection, the fact that these patients eventually had that complication is a finding that is novel and worth reporting. Strengths of the study include the accuracy of data that was manually extracted from patient charts, a relatively large cohort and using a systematic approach for multivariable analysis.

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Figure Legend:

Figure 1. Adjusted odds of Mortality in patients hospitalized with Covid-19
Table 1. Characteristics and Outcomes of patients admitted with Covid-19

| Patient Characteristics | Overall (n=327) | Patients with AKI (n=179) | Patients without AKI (n=148) | P value |
|-------------------------|----------------|--------------------------|---------------------------|---------|
| **Demographics**        |                |                          |                           |         |
| Age (years), IQR        | 71 (59–82)     | 75 (63–85)               | 67 (53.5–78)              | <.001   |
| Male Gender (%)         | 182 (55.7)     | 101 (56.4)               | 81 (54.7)                 | .8      |
| Race/Ethnicity (%)      |                |                          |                           |         |
| White                   | 111 (33.9)     | 60 (33.5)                | 51 (34.5)                 | .9      |
| African American        | 116 (35.5)     | 77 (43.02)               | 39 (26.4)                 | .002    |
| Hispanic                | 65 (19.9)      | 26 (14.5)                | 39 (26.4)                 | .01     |
| Other                   | 35 (10.7)      | 16 (8.9)                 | 19 (12.8)                 | .3      |
| Admission Source Home   | 212 (64.8)     | 108 (60.3)               | 104 (70.3)                | .06     |
| Insurance (%)           |                |                          |                           |         |
| Medicare                | 125 (38.2)     | 70 (39.1)                | 55 (37.2)                 | .7      |
| Medicaid                | 42 (12.8)      | 21 (11.7)                | 21 (14.2)                 | .5      |
| Private Insurance       | 147 (44.9)     | 84 (46.9)                | 63 (42.6)                 | .4      |
| Self-pay or Other       | 13 (3.9)       | 4 (2.2)                  | 9 (6.1)                   | .08     |
| **Comorbidities (%)**   |                |                          |                           |         |
| Hypertension            | 209 (63.9)     | 126 (70.4)               | 83 (56.1)                 | .01     |
| Diabetes Mellitus       | 139 (42.5)     | 87 (48.6)                | 52 (35.1)                 | .01     |
| Hyperlipidemia          | 114 (34.9)     | 76 (42.5)                | 38 (25.7)                 | .001    |
| Condition                      | Median (IQR) | Number (Percentage) | p-value |
|-------------------------------|--------------|---------------------|---------|
| Cardiac Disease               | 98 (29.9)    | 59 (32.9)           | 39 (26.4) | .2     |
| Chronic Kidney Disease        | 40 (12.2)    | 33 (18.4)           | 7 (4.7)  | <.001  |
| COPD                          | 44 (13.5)    | 24 (13.4)           | 20 (13.5) | .9     |
| Stroke or Dementia            | 91 (27.8)    | 59 (32.9)           | 32 (21.6) | .02    |
| Smoking                       | 56 (17.1)    | 29 (16.2)           | 27 (18.2) | .6     |
| Malignancy                    | 66 (20.2)    | 36 (20.1)           | 30 (20.3) | .9     |
| Obesity                       | 113 (34.6)   | 63 (35.2)           | 50 (33.8) | .8     |
| Mortality                     | 133 (40.7)   | 104 (58.1)          | 29 (19.6) | <.001  |

* COPD = chronic obstructive pulmonary disease.

* Data presented as median with inter-quartile range and number (percentage).

* Difference in median and percentage were calculated by using the Mann-Whitney and chi-squared test respectively.
Table 2. Odds of AKI in patients with hospitalized with Covid-19

| Demographics and Clinical Characteristics | Age & Sex adjusted Odds | $P$ value | Multivariable analysis | $P$ value |
|------------------------------------------|------------------------|-----------|------------------------|-----------|
| **Demographics**                         |                        |           |                        |           |
| Age                                      | –                      | –         | 1.03 (1.01–1.05)       | .007      |
| Male gender (vs female)                  | –                      | –         | 1.3 (0.8–2.2)          | .3        |
| Race (vs White)                          | –                      | –         |                        |           |
| African-American                         | 2.1 (1.2–3.7)          | .01       | 2.01 (1.1–3.6)         | .02       |
| Hispanic                                 | 0.9 (0.4–1.7)          | .7        | 0.9 (0.4–1.8)          | .7        |
| Others                                   | 0.8 (0.4–1.8)          | .6        | 0.7 (0.3–1.6)          | .4        |
| NH Admit (vs Home)                       | 1.01 (0.6–1.7)         | .9        | –                      | –         |
| Insurance (vs Medicare)                  | –                      | –         |                        |           |
| Medicaid                                 | 2.3 (0.9–5.4)          | .07       | –                      | –         |
| Private                                  | 1.7 (0.9–2.9)          | .07       | –                      | –         |
| Others                                   | 0.7 (0.2–2.4)          | .5        | –                      | –         |
| **Comorbidities**                        |                        |           |                        |           |
| Hypertension                             | 1.4 (0.9–2.3)          | .2        | 0.9 (0.5–1.6)          | .7        |
| Diabetes Mellitus                        | 1.7 (1.1–2.7)          | .03       | 1.5 (0.9–2.4)          | .1        |
| Hyperlipidemia                           | 1.8 (1.1–2.9)          | .02       | 1.8 (1.04–3.01)        | .03       |
| Cardiac Disease                          | 0.9 (0.6–1.7)          | .9        | 0.8 (0.5–1.4)          | .4        |
| CKD                                      | 3.7 (1.6–8.9)          | .003      | 3.3 (1.4–7.9)          | .008      |
| Condition                  | Odds Ratio (95% CI) | p-Value | Adjusted for | NH |
|---------------------------|---------------------|---------|--------------|-----|
| COPD                      | 0.8 (0.4–1.5)       | .4      | –            | –   |
| Stroke or Dementia        | 1.2 (0.7–2.1)       | .6      | –            | –   |
| Smoking                   | 0.7 (0.4–1.3)       | .3      | –            | –   |
| Malignancy                | 0.8 (0.4–1.4)       | .4      | –            | –   |
| BMI class (kg/meter\(^2\))| –                   | –       | –            | –   |
| (vs Normal, 18.5–24.9)    |                      |         |              |     |
| Overweight, 25–29.9       | 0.6 (0.3–1.01)      | .06     | –            | –   |
| Obese, >=30               | 1.05 (0.6–1.9)      | .9      | –            | –   |
| Underweight <18.5         | 0.5 (0.1–1.9)       | .3      | –            | –   |

\(^a\) BMI = body mass index, CKD = Chronic kidney disease, COPD = Chronic obstructive pulmonary disease, NH = Nursing home.

\(^b\) Odds adjusted for race, hyperlipidemia, chronic kidney disease in addition to six essential covariates (age, sex, race, hypertension, diabetes, cardiac disease).
Table 3. Odds of Mortality with Acute Kidney Injury in Patients hospitalized with Covid-19

| Demographics and Clinical Characteristics | Age & Sex adjusted Odds | P value | Multivariable analysis P value |
|------------------------------------------|-------------------------|---------|-------------------------------|
| AKI                                      |                         |         |                               |
| Stage 1                                  | 2.7 (1.4–5.2)           | .003    | 2.8 (1.002–7.8)               | .049 |
| Stage 2                                  | 5.1 (2.4–10.9)          | <.001   | 3.3 (1.05–10.5)               | .04  |
| Stage 3                                  | 9.2 (4.6–18.3)          | <.001   | 4.8 (1.6–14.5)                | .01  |
| ARDS                                     | 38.1 (17.4–83.4)        | <.001   | 32.6 (12.8–83.6)              | <.001|
| Demographics                             |                         |         |                               |
| Age                                      | –                       | –       | 1.06 (1.03–1.1)               | <.001|
| Male gender (vs female)                  | –                       | –       | 1.5 (0.7–3.3)                 | .3   |
| Race (vs White)                          | –                       | –       | –                             | –    |
| African-American                         | 0.8 (0.5–1.4)           | .5      | 0.4 (0.2–1.1)                 | .08  |
| Hispanic                                 | 1.5 (0.7–2.9)           | .3      | 0.6 (0.2–2.1)                 | .4   |
| Others                                   | 0.6 (0.2–1.3)           | .2      | 0.5 (0.1–1.9)                 | .3   |
| NH Admit (vs Home)                       | 1.4 (0.8–2.3)           | .3      | –                             | –    |
| Insurance (vs Medicare)                  | –                       | –       | –                             | –    |
| Medicaid                                 | 1.4 (0.6–3.4)           | .5      | –                             | –    |
| Private                                  | 0.7 (0.4–1.2)           | .2      | –                             | –    |
| Others                                   | 0.8 (0.2–3.2)           | .8      | –                             | –    |
| Comorbidities                            |                         |         |                               |
| Condition                  | Odds Ratio (95% CI) | p-value | Odds Ratio (95% CI) | p-value |
|----------------------------|---------------------|---------|---------------------|---------|
| Hypertension               | 1.1 (0.7–1.8)       | .7      | 0.6 (0.2–1.3)       | .2      |
| Diabetes Mellitus          | 1.3 (0.8–2.1)       | .2      | 1.1 (0.5–2.3)       | .9      |
| Hyperlipidemia             | 1.4 (0.8–2.2)       | .2      | –                   | –       |
| Cardiac Disease            | 1.1 (0.7–1.9)       | .7      | 1.7 (0.7–3.9)       | .2      |
| CKD                        | 0.8 (0.4–1.6)       | .5      | –                   | –       |
| COPD                       | 0.7 (0.4–1.4)       | .3      | –                   | –       |
| Stroke or Dementia         | 1.1 (0.6–1.9)       | .7      | –                   | –       |
| Smoking                    | 0.8 (0.4–1.5)       | .5      | –                   | –       |
| Malignancy                 | 1.2 (0.7–2.1)       | .5      | –                   | –       |
| BMI class                  | –                   | –       | –                   | –       |
| (kg/meter²), (vs Normal, 18.5-24.9) | –                   | –       | –                   | –       |
| Overweight, 25 - 29.9      | 1.8 (1.01–3.3)      | .047    | 1.9 (0.7–5.5)       | .2      |
| Obese, >=30                | 2.2 (1.1–4.1)       | .02     | 1.6 (0.6–4.3)       | .4      |
| Underweight <18.5          | 1.3 (0.3–5.4)       | .8      | 1.3 (0.1–14.9)      | .8      |

*a ARDS = Acute respiratory distress syndrome, BMI = Body mass index, CKD = Chronic kidney disease, COPD = Chronic obstructive pulmonary disease, NH = Nursing home.

*b Odds adjusted for acute kidney injury, acute respiratory distress syndrome, body-mass index class in addition to six essential covariates (age, sex, race, hypertension, diabetes, cardiac disease).
Odds of Mortality in Covid-19 Patients

| Condition            | Odds Ratio (CI) | P value |
|----------------------|-----------------|---------|
| AKI Stage 1          | 2.8 (1.002–7.8) | .049    |
| AKI Stage 2          | 3.3 (1.05–10.5) | .04     |
| AKI Stage 3          | 4.8 (1.6–14.5)  | .01     |
| ARDS                 | 32.6 (12.8–83.6) | <.001 |
| Age                  | 1.06 (1.03–1.1) | <.001  |
| Male sex             | 1.3 (0.7–3.3)   | .3      |
| African-American     | 0.4 (0.2–1.3)   | .08     |
| Hispanic             | 0.6 (0.2–2.3)   | .4      |
| Other ethnicities    | 0.5 (0.1–1.9)   | .3      |
| Hypertension         | 0.6 (0.2–1.3)   | .2      |
| Diabetes             | 1.1 (0.5–2.3)   | .9      |
| Cardiac disease      | 1.7 (0.7–3.9)   | .2      |
| BMI–Underweight      | 1.9 (0.7–5.5)   | .2      |
| BMI–Overweight       | 1.6 (0.6–4.3)   | .4      |
| BMI–Obese            | 1.3 (0.1–14.9)  | .8      |
Instructions

The purpose of this form is to provide readers of your manuscript with information about your other interests that could influence how they receive and understand your work. The form is designed to be completed electronically and stored electronically. It contains programming that allows appropriate data display. Each author should submit a separate form and is responsible for the accuracy and completeness of the submitted information. The form is in four parts.

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Section 1: Identifying information

First Name Michael
Last Name Mandel
Manuscript No.: MCPIQO-2020-0101
Manuscript Title: Incidence and risk factors for acute kidney injury ...
Date Submitted: June 11, 2020

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| 3. Support for travel to meetings for the study or other purposes    | X  |                   |                             |                |            |
| 4. Fees for participation in review activities such as data monitoring boards, statistical analysis, end point committees, and the like | X  |                   |                             |                |            |
| 5. Payment for writing or reviewing the manuscript                   | X  |                   |                             |                |            |
| 6. Provision of writing assistance, medicines, equipment, or administrative support | X  |                   |                             |                |            |
| 7. Other                                                             | X  |                   |                             |                |            |

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|--------------------------------------|----|-------------------|-----------------------------|--------|----------|
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| 2. Consultancy       | X |
| 3. Employment       | X |
| 4. Expert testimony | X |
| 5. Grants/grants pending | X |
| 6. Payment for lectures including service on speakers bureaus | X |
| 7. Payment for manuscript preparation | X |
| 8. Patents (planned, pending or issued) | X |
| 9. Royalties        | X |
| 10. Payment for development of educational presentations | X |
| 11. Stock/stock options | X |
| 12. Travel/accommodations/meeting expenses unrelated to activities listed** | X |
| 13. Other (err on the side of full disclosure) | X |

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**Instructions**

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**Section 1: Identifying information**

| First Name: Ashutossh | Last Name: Naaraayan |
|------------------------|----------------------|
| Manuscript No.: MCPIQO-2020-0101 |
| Manuscript Title: Incidence and Risk Factors for Acute Kidney Injury and its effect on Mortality in Patients Hospitalized from Covid-19 |
| Date Submitted: July 2, 2020 |

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| 3. Support for travel to meetings for the study or other purposes    | X  |                   |                           |                |            |
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| 5. Payment for writing or reviewing the manuscript                   | X  |                   |                           |                |            |
| 6. Provision of writing assistance, medicines, equipment, or administrative support | X  |                   |                           |                |            |
| 7. Other                                                             | X  |                   |                           |                |            |

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| 1. Board membership                         | X  |                   |                           |        |          |
|   |   |   |
|---|---|---|
| 2. Consultancy | X |   |
| 3. Employment | X |   |
| 4. Expert testimony | X |   |
| 5. Grants/grants pending | X |   |
| 6. Payment for lectures including service on speakers bureaus | X |   |
| 7. Payment for manuscript preparation | X |   |
| 8. Patents (planned, pending or issued) | X |   |
| 9. Royalties | X |   |
| 10. Payment for development of educational presentations | X |   |
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