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Early Clinical and Sociodemographic Experience with Patients

Hospitalized with COVID-19 at a Large American Healthcare System

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5 **Abstract**

6 **Background:** Despite over 4 million cases of novel coronavirus disease 2019 (COVID-19) in
7 the United States, limited data exist including socioeconomic background and post-discharge
8 outcomes for patients hospitalized with this disease.

9 **Methods:** In this case series, we identified patients with COVID-19 admitted to 3 Partners
10 Healthcare hospitals in Boston, Massachusetts between March 7th, 2020, and March 30th, 2020.
11 Patient characteristics, treatment strategies, and outcomes were determined.

12 **Findings:** A total of 247 patients hospitalized with COVID-19 were identified; the median age
13 was 61 (interquartile range [IQR]: 50-76 years), 58% were men, 30% of Hispanic ethnicity, 21%
14 enrolled in Medicaid, and 12% dual-enrolled Medicare/Medicaid. The median estimated
15 household income was \$66,701 [IQR: \$50,336-\$86,601]. Most patients were treated with
16 hydroxychloroquine (72%), and statins (76%; newly initiated in 34%). During their admission,
17 103 patients (42%) required intensive care. At the end of the data collection period (June 24,
18 2020), 213 patients (86.2%) were discharged alive, 2 patients (0.8%) remain admitted, and 32
19 patients (13%) have died. Among those discharged alive (n=213), 70 (32.9%) were discharged to
20 a post-acute facility, 31 (14.6%) newly required supplemental oxygen, 19 (8.9%) newly required
21 tube feeding, and 34 (16%) required new prescriptions for antipsychotics, benzodiazepines,
22 methadone, or opioids. Over a median post-discharge follow-up of 80 days (IQR, 68-84), 22
23 patients (10.3%) were readmitted.

- 1 **Interpretation:** Patients hospitalized with COVID-19 are frequently of vulnerable
- 2 socioeconomic status and often require intensive care. Patients who survive COVID-19
- 3 hospitalization have substantial need for post-acute services.
- 4 **Funding:** American Heart Association

Introduction

In December 2019, a cluster of severe pneumonia in China, led to the discovery of a novel coronavirus,¹ named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), that causes novel coronavirus disease 2019 (COVID-19).² Since December 2019, the viral outbreak has expanded to a global pandemic.

Despite more than 4 million cases in the United States, limited clinical data exist across diverse settings. Patient characteristics, testing, treatment strategies, inpatient and post-discharge outcomes may vary substantially among different countries and regions. Additionally, concerns have emerged regarding racial disparities in prevalence and outcomes;³ however, information on socioeconomic status, insurance, and professional occupations is lacking. This information may inform urgent policy needs.

In this study, a detailed physician-reviewed registry was created to evaluate inpatients with COVID-19 within an integrated healthcare network in Boston, Massachusetts. The goals of the registry were to define characteristics including demographics and professions, treatment strategies, clinical outcomes, and adverse event rates (inclusive of subclinical outcomes from electrocardiographic data), that may inform patient care, public policy, and clinical trials.

Methods

Study Population

Patients were included if hospitalized with confirmed SARS-CoV-2 infection at three Partners Healthcare hospitals (Massachusetts General Hospital, Brigham and Women's Hospital, and Newton-Wellesley Hospital) between March 7, 2020 and March 30, 2020. These represent three

of the largest hospitals of the largest health care system in New England. Healthcare workers with personal connections to the investigators were excluded (one patient).

Patient demographics, baseline characteristics, symptoms, home medications, laboratory data, electrocardiogram (EKG) data, imaging, and treatment strategies were obtained by physician chart review. In order to improve standardization, one physician (C.M.C) reviewed a random 10% sample of the other reviewer's data collection to ensure consistency in data collection. Physicians reviewed patient charts across each of the three hospitals which were connected through a shared electronic health record system. Median zip code household income based on 2014 census data was used as a proxy for household income. Employment and insurance status were recorded. The first laboratory tests within 48 hours of admission were considered the presenting values. When serial laboratory testing was performed, the peak value was recorded.

For patients prescribed hydroxychloroquine, the QTc interval prior to initiation and on subsequent EKGs was recorded. Prolonged QTc was defined as greater than 450ms in men and 470ms in women within 7 days of drug initiation.⁴ For those with a prolonged baseline QTc interval, further prolongation was considered to be an increase of 60ms or more or an increase above 500ms. Among patients with a left or right bundle branch block, the QTc was adjusted according to the following formula: $QTc = QTc - (QRS - 100ms)$. For patients admitted to the intensive care unit (ICU), use of paralytic agents, vasopressors, inhaled nitric oxide, epoprostenol, and mechanical circulatory support devices was recorded. Data collection ended on June 24, 2020.

Outcomes

Outcomes recorded included all-cause mortality, ICU admission, and cardiovascular mortality (defined as death attributed to ventricular tachycardia/fibrillation, cardiogenic shock, or acute

myocardial infarction [MI]). Cardiovascular events, including cardiogenic shock, MI, acute heart failure, stroke, myocarditis, pericarditis, atrial fibrillation or atrial flutter, ventricular tachycardia, stress cardiomyopathy, coronary vasospasm, and venous thromboembolism (VTE), were collected by using all available in-hospital data. Subtypes of MI were defined by the Universal definition of MI.⁵ Other non-cardiovascular outcomes included acute kidney injury (AKI) according to the Kidney Disease: Improving Global Outcomes Clinical Practice Guidelines and acute respiratory distress syndrome (ARDS), according to the Berlin definition.^{6,7} Requirement for supplemental oxygen, tube feeding, and new prescriptions for opioids, benzodiazepines, and antipsychotics on discharge were recorded. Post-discharge Emergency Department presentations and readmission were determined.

Statistical Analysis

Descriptive statistics were used to summarize data. Baseline characteristics, diagnostic testing, treatments, and outcomes were reported as counts and percentages, medians and 1st and 3rd quantiles, or means and standard deviations, as appropriate. Patients who either died or were admitted to the ICU were compared with those who were discharged alive without an ICU stay using Wilcoxon rank sum test for continuous variables or Fisher's exact test for categorical measurements.

Statistical tests were 2-sided, with $p < 0.05$ considered significant. All analyses were performed using R software (version 3.6.2). The study was approved by the Partners Healthcare Institutional Review Board and informed consent was waived based on secondary use of data from medical record review.

Role of funding source

The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Results

A total of 247 patients with COVID-19 were identified over the study period; 147 patients (59.5%) were admitted to Massachusetts General Hospital, 52 patients (21.1%) to Brigham and Women's Hospital, and 48 patients (19.4%) to Newton Wellesley Hospital. Three patients were diagnosed with COVID-19 at outside facilities, the remaining 244 were diagnosed by SARS-CoV-2 PCR within the system. Among patients hospitalized with COVID-19, 51 (20.6%) were admitted directly to the ICU from Emergency Departments.

Baseline Characteristics

Baseline characteristics are displayed in **Table 1** for all patients and stratified by ICU stay at any time or death for patients with either outcome (N=247). The median age was 61 years (interquartile range [IQR], 50 -76), and 57.9% were men. Hispanic and Black patients represented 30.4% and 9.7% of the cohort, respectively. Estimated household income was \$66,701 (IQR, \$50,336-\$86,601). White and Asian patients had higher median incomes than black patients (**Supplementary Table 1**) and Hispanic patients were younger than non-Hispanic patients (**Supplementary Table 2**). 90 patients (36.4%) had private insurance, 71 patients (28.7%) had Medicare/Medicare Advantage, 51 patients (20.7%) had Medicaid, and 30 patients (12.1%) were dual-enrolled in Medicare/Medicaid. Employment data were identified in 204 patients (83%): 89 patients (36%) were retired, 23 patients (9.3%) worked in hospitality, 10 patients (4%) were healthcare workers, 5 patients (2%) worked in public transportation, and 21 (8.5%) were unemployed.

Commonly reported symptoms were cough (83%), fever (81.8%), shortness of breath (70.9%), altered sense of taste (9.7%) and smell (6.1%). Median time from onset of symptoms to admission was 7 days (IQR, 4-10). Obesity or being overweight was common (n=187; 75.7%) and 81 patients (32.8%) had current or former tobacco use. Hypertension (n=128; 51.8%), hyperlipidemia (n=109; 44.1%), diabetes mellitus (n=68; 27.5%), and a history of malignancy (n=46; 18.6%) were also prevalent. On admission, 59 patients (23.9%) were taking an angiotensin-converting-enzyme inhibitor (ACEi) or angiotensin II receptor blockers (ARB), 53 patients (21.5%) were taking a beta-receptor antagonist, and 29 patients (11.7%) were taking a non-steroidal anti-inflammatory drug (NSAID).

Compared with patients who were discharged alive without ICU care (n=135), patients who required ICU care or who died (n= 112) were older (median age, 63.5 years [IQR, 52.5-77.3] versus 58 years [IQR, 45-72], p=0.04) and more often presented with shortness of breath (82.1% versus 61.5%, p<0.001) (**Table 1**).

Diagnostic Testing

Laboratory data on admission and peak values are reported in **Table 2** for all patients (N=247) and then stratified by ICU stay at any time or death for those who experienced either outcome. Compared with patients who were discharged alive without ICU care (n=135), patients who required ICU care or who died (n= 112), had higher initial median serum levels of white blood cells (7.2 K/ μ L [IQR, 5-9.2]) vs. 6 K/ μ L [IQR, 4.6-8.3]), procalcitonin (0.23 ng/ml [IQR, 0.13-0.48] vs. 0.12 ng/ml [IQR, 0.08-0.19]), creatinine (1.05 mg/dL [IQR, 0.8-1.29] vs. 0.94 mg/dL [IQR, 0.76-1.12]), lactate dehydrogenase (362 U/L [IQR, 290-507] vs. 276 U/L [IQR, 221-335]), aspartate aminotransferase (46 U/L [IQR, 34-70] vs. 35 U/L [IQR, 25-53]), ferritin (777 ug/L [IQR, 363-1304] vs. 577 ug/L [IQR, 241-835]), creatinine kinase (152 U/L [IQR, 84-400] vs. 90

U/L [IQR, 55-172]), erythrocyte sedimentation rate (42 mm/h [IQR, 26-64] vs. 35 mm/h [IQR, 17-53]), C-reactive protein (95 mg/L [IQR, 54-202] vs. 41 mg/L (14.8-91.4), D-dimer (1,072 ng/ml [IQR, 703-1625]) vs. 704 ng/ml [IQR, 491-1190]), and NT-proBNP (341 pg/ml [IQR, 105-1430] vs. 97 pg/ml [IQR, 24-429]). Admission EKG data and results of chest imaging, transthoracic echocardiography and bedside cardiac ultrasonography (either performed anytime during admission) are reported in the **Supplementary Table 3**. Patients who were admitted to the ICU or who died were more likely to have bilateral lung opacities (81.2% vs. 56.8%, $p=0.002$), pulmonary edema (19.6% vs. 8.3%, $p=0.04$), and pleural effusions (8% vs. 1.5%, $p=0.03$) than were those who were discharged alive without an ICU stay.

Treatments

The majority of patients ($n=203$; 82.2%) received antibiotics. Of these, 182 patients (73.7%) received azithromycin (**Table 3**). Hydroxychloroquine was also frequently prescribed ($n=177$; 71.7%). Of those who received hydroxychloroquine, 172 patients (97%) had an EKG prior to initiation of the drug. Of those, 4 patients (2.3%) had a QTc interval of >500 ms prior to initiation. Among those initiated on hydroxychloroquine with available EKG data ($n=172$), 65 patients (37.8%) developed QTc prolongation. Among those with a QTc of <500 ms prior to drug initiation ($n=168$), 28 patients (16.7%) developed a QTc of ≥ 500 ms. QTc prolongation occurred in 58 of the 146 patients (39.7%) who received both hydroxychloroquine and azithromycin during admission and 7 of the 26 patients (26.9%) who received hydroxychloroquine alone. Among those who did not receive hydroxychloroquine ($N=70$), 65 patients had an admission EKG of whom 10 had a baseline QTc prolongation and a further 7 developed QTc prolongation within 7 days of admission (17 total, 26.2%). Two of the 65 patients who did not receive hydroxychloroquine and had EKG data available developed a QTc of ≥ 500 ms within 7 days of

admission (3.1%); lower than those treated with hydroxychloroquine (16.7%, $p=0.004$). Hydroxychloroquine was discontinued in 11 patients due to QTc prolongation (6.2%). One patient, who received both hydroxychloroquine and azithromycin, developed torsades de pointes.

Prescription of a statin was common: 187 patients (75.7%) received a statin during admission (initiated during hospitalization in 85 patients; 45.5%). Discontinuation of statin was common (55 of 187 patients; 29.4%: 28 [15%] due to a creatine kinase elevation and 27 [14.4%] due to elevated liver biochemical test levels). Peak creatine kinase levels were higher among those who received a statin (median, 282 U/L: IQR, 116-737) than those who did not (median, 156 U/L: IQR, 84-342, $p=0.02$). Among those who received a statin, peak creatine kinase levels were higher among those who received azithromycin (median, 344 U/L: IQR, 122-872) than those who received a statin alone (median, 207 U/L: IQR, 98-306.5, $p=0.02$).

The majority of patients received venous thromboembolism prophylaxis or therapeutic anticoagulation ($n=238$; 96.4%). A glucocorticoid was prescribed to 52 patients (21.1%) at least once during their admission (newly initiated in 36; 69.2%), and tocilizumab was prescribed to 12 patients (4.9%). Enrollment in a clinical trial was common; 57 patients (23.1%) for remdesivir, 7 patients (2.8%) for sarilumab, and 21 patients (8.5%) received inhaled nitric oxide, of which 11 patients were enrolled in a clinical trial.

In-hospital Outcomes

At the end of the follow-up period, 213 patients (86.2%) were discharged alive, 2 (0.8%) remained hospitalized, and 32 died in hospital (13%). Among patients who died ($n=32$), median time from symptom onset to death was 19 days (IQR, 12.5-28). Three deaths were attributed to cardiovascular causes (**Table 4**). The median age of those who died was 78 years (IQR, 64.8-84).

Through the end of the follow-up period, 103 patients (41.7%) required intensive care; 51 patients were admitted directly from the Emergency Department, 6 were transferred from an outside hospital ICU, and 46 patients were transferred from a general hospital floor. The median time from the onset of symptoms to ICU admission was 7.5 days (IQR, 6.25 -10). Among those initially admitted to a hospital floor (n=46), median time to ICU transfer was 2 days (IQR, 1-3.8). ARDS was diagnosed in 90 patients (87.4%); the majority (63.3%) had moderate ARDS. Among those admitted to the ICU, 90 patients (87.4%) required mechanical ventilation, 91 (88.3%) received vasopressors, 54 (52.4%) underwent prone positioning, 39 (37.9%) received infusion of a paralytic agent, and 4 (3.9%) required ECMO. Among those requiring intubation (n=90), 46 were intubated in the ICU, 26 in the Emergency Department, 10 on the medicine floor, and 8 at outside facilities. Of those requiring mechanical ventilation (n=90), 78.9% were subsequently extubated. Among patients admitted to the ICU (n=103), 79 (76.7%) were transferred to a general medical floor, 23 (22.3%) have died, and 1 (1%) remain in the ICU (**Table 4**). Race/ethnicity was not associated with risk of death or ICU admission in logistic regression analysis (**Supplementary Table 4**).

Cardiovascular events are reported in **Table 4**. MI (all type 2) occurred in 12 patients (4.9%), stroke in 1 (0.4%), stress cardiomyopathy in 3 (1.2%), acute heart failure in 19 (7.7%), new atrial fibrillation/flutter in 21 (8.5%), ventricular tachycardia (non-sustained or sustained) in 23 (9.3%), pericarditis in 2 (0.8%), and coronary vasospasm in 1 (0.4%). One case of myocarditis was diagnosed clinically (0.4%) and treated with intravenous immunoglobulin.

A computed tomographic (CT) pulmonary angiogram or extremity venous doppler ultrasound was performed in 57 patients (23.1%) to assess for VTE, which was detected in 12 patients (4.9% of all patients and 21.1% of those who underwent testing for suspicion of VTE).

Among those who underwent imaging evaluation for VTE (n=57), serum D-dimer concentration was higher among patients diagnosed with a thromboembolism compared with others: 5761 ng/mL (IQR, 3374-9955) versus 1,595 ng/mL (IQR, 996-3971), p=0.003. AKI was common, occurring in 86 patients (34.8%); 17 patients (6.9%) required renal replacement therapy. AKI occurred in 57 patients (55.3%) who required an ICU stay (N=103) and in 29 patients (20.1%) who did not require an ICU stay (N=144).

Morbidity at Discharge and Post-Discharge Outcomes

Among those discharged alive (n=213), the median length of stay was 9 days (IQR, 5-18). Delirium was diagnosed in 62 patients (29.1%). Among those who required intensive care (n=78; 36.6%), 20 (25.6%) were diagnosed with critical illness myopathy, and 28 patients (35.9%) received medications to prevent or treat sedative withdrawal.

At discharge, 31 patients (14.6%) newly required supplemental oxygen, 19 patients (8.9%) required tube feeding (11 via percutaneous gastrostomy tube and 8 via nasogastric tube), 14 patients (5.7%) had a tracheostomy, and one patient (0.5%) required hemodialysis. On discharge, 18 patients (8.5%) were newly prescribed antipsychotics, 7 (3.3%) benzodiazepines, 4 (1.9%) methadone, and 5 (2.3%) opioids.

Upon leaving the hospital, 143 (67.1%) were discharged home and 70 (32.9%) to a facility. The median post-discharge follow-up was 80 (IQR, 68-84) days. Following discharge, 36 patients (16.9%) re-presented to the Emergency Department, and 22 (10.3%) were readmitted. The median time from discharge to readmission was 19 (IQR, 8-32) days. The three most common reasons for readmission (**Supplementary Table 5**) were persistent COVID-19 symptoms (4/22, 18.2%), pneumonia (3/22, 13.6%), and pulmonary embolism (2/22, 9.1%). Over the follow-up period, four patients died.

Discussion

In this case series, we demonstrate that among patients hospitalized with COVID-19, one-third were insured by (including Medicare/Medicaid dual-enrollment) and almost a third were Hispanic. In this very early experience before later guidelines, off-label prescription of hydroxychloroquine, azithromycin, and statins was common.^{8,9} Clinical trial enrollment for other therapies was common. Although intensive care utilization was frequent (42%), the majority of hospitalized patients were discharged alive (86%). However, survivors of COVID-19 have substantial new comorbidities and needs after discharge.

Our finding about high rates of hospitalization of Hispanic patients is consistent with concerns regarding racial disparities.³ Frequent emergency department utilizers at Massachusetts General Hospital have reported a ~72% proportion of white patients,¹⁰ compared with only 51% in this study. The proportion of Hispanic patients admitted with COVID-19 in our cohort is also higher than in New York City (23%).¹¹ We extend those findings and report that one third of patients were insured by Medicaid or dual-enrolled, although the median estimated household income of \$66,701 is only slightly lower than the state median household income for that year (\$71,681)¹². Because the two ways we estimated wealth produce different results, we believe the zip-code estimates may mask ecological-inference bias (i.e., poorer patients in middle-class zip codes). The high proportion of Medicaid patients and hospitality workers could be related to financial vulnerability requiring patients to work and limiting their ability to self-isolate. Because nearly half of the sample were retired or unemployed, these results also suggest the possibility of non-occupational spread; however, this requires further evaluation through contact tracing and mechanistic studies. It is also possible that this cohort were more vulnerable to severe infection (requiring hospitalization) due to differences in demographics.

1 This study also describes early experience with treatment strategies and detailed
2 information regarding side effects and clinical trial enrollment. We found a high rate of off-label
3 medication use for COVID-19 at the start of the pandemic. In light of observational studies
4 suggesting that statins might reduce mortality in patients with influenza,^{13,14} use of statin therapy
5 to treat COVID-19 was common. However, in a noteworthy number of patients the drug was
6 discontinued due to adverse events; which may be exacerbated when combined with
7 azithromycin.¹⁵ Furthermore, following demonstration of *in vitro* activity of hydroxychloroquine
8 in inhibiting SARS-CoV-2,¹⁶ early attention had shifted toward this anti-malarial agent. In this
9 early experience, we found high proportions of patients treated with both hydroxychloroquine
10 and azithromycin. QTc prolongation was common and there was one non-fatal episode of
11 polymorphic ventricular tachycardia. These findings dovetail with more recent concerns about
12 the safety profile of chloroquine¹⁷ and recent guidance from the National Institutes of Health
13 advising against hydroxychloroquine or statins outside of a trial.⁸ Off-label use of these agents is
14 now uncommon at our institutions, highlighting the dynamic nature of COVID-19 evidence.
15 Encouragingly, enrollment in clinical trials was common early in the pandemic, occurring in
16 approximately one-third of patients in this report.

17 These data suggest that hospital mortality may not differ significantly across the United
18 States. Our hospital mortality rate of ~13% is similar to one New York study¹⁸ and California
19 study¹⁹ but lower than another study from New York (although one in which over half of the
20 study population was still admitted at the time of the report).¹¹ ICU stay rates among COVID-19
21 hospitalized patients also appear similarly high across the United States. Comparable to data
22 from California¹⁹ and New York City¹⁸, we found high ICU admission rates, with 42% of study
23 patients spending time in the ICU. Notably, patients typically presented to the hospital 7 days

1 after onset of symptoms, and 21% of patients were admitted directly to ICUs from the
2 Emergency Department.

3 Coronary events were infrequent with low rates of MI (4.9%), similar in frequency to that
4 found in New York City (3.6%).¹⁸ Arrhythmias were more common; 8.5% had new atrial
5 fibrillation/flutter and ventricular tachycardia occurred in 9.3%. Precipitating factors for these
6 arrhythmias may be multifactorial with contributions from myocardial injury (present in more
7 than half on admission), systemic inflammation, and critical illness.

8 Hypercoagulability has been a concern in patients with COVID-19;²⁰ however, patients
9 included in prior studies have often lacked VTE prophylaxis²¹ or the frequencies of VTE
10 prophylaxis and image testing were not reported to contextualize the results.¹⁸ We found a
11 relatively low rate of VTE at 4.9%. The majority of patients were either on VTE prophylaxis or
12 therapeutic anticoagulation for various indications. Although our low event rate could be
13 explained by under-ascertainment, a reasonable proportion of patients (23%) underwent
14 evaluation for VTE with imaging during admission. Most patients with COVID-19 had an
15 elevated serum D-dimer on admission, potentially limiting the diagnostic utility of this
16 biomarker. Nevertheless, at the time of testing for VTE, the D-dimer concentration was
17 significantly higher among those who were diagnosed with a VTE.

18 Our analyses emphasize that even survivors of COVID-19 have substantial needs after
19 discharge. One quarter of patients discharged alive had experienced delirium during their
20 admission, and among those who had an ICU stay, a quarter were diagnosed with critical illness
21 myopathy, and over a third received medications to prevent or treat sedative withdrawal. Nearly
22 a third of patients required post-acute care, and one in seven required supplemental oxygen, one
23 in eleven required tube feeding, and one in six required new prescriptions for antipsychotics,

1 benzodiazepines, methadone, or opioids on discharge. Among patients who required
2 readmission, 41% were due to persistent COVID-19 symptoms, pneumonia, or pulmonary
3 embolism.

4 Our study has important limitations. First, because two patients included in this study
5 remained admitted at the end of the study period, event rates may be under-reported. In
6 particular, patients alive at closing of data analysis may die later, which would underestimate the
7 reported fatality rate. Second, because this is a retrospective observational study, data collection
8 is limited to that documented and reported in the electronic medical record. Nevertheless, all data
9 were obtained by physician review as opposed to being queried from either claims data, or EHR
10 data. Third, whether findings in this study are generalizable to other regions of the country is
11 unknown and therefore the results should be interpreted with caution. An important strength of
12 this analysis is the inclusion of multiple hospitals including a community teaching hospital.
13 Fourth, since this was a retrospective analysis, only 45 of the 257 patients had all initial
14 laboratory tests, and as such we could not develop a predictive algorithm using multivariable
15 analysis given the limitations of missing data. Lastly, readmissions to outside facilities and out-
16 of-hospital mortality may not have been captured in our medical record system.

17 In conclusion, we demonstrate socioeconomic vulnerability and frequent off-label use of
18 medications early in the pandemic among patients hospitalized with COVID-19. Patients who
19 survive COVID-19 hospitalization have substantial morbidity and need for post-acute services.

1 **Declaration of Interests**

2 Dr. Bohula reports personal fees from Servier, personal fees from Merck, personal fees from
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23 this topic. The remaining authors have no conflicts of interest to disclose.

Data sharing statement

Request for access to the data should be made to the corresponding author and will be reviewed on a case to case basis. Data could potentially be made available provided the applicant has appropriate ethics approval and approval from the authors.

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Author Contributions

Drs. McCarthy, Murphy, Jones-O'Connor, Olshan, Khambhati, Rehman, and Mr. Cadigan performed the data collection. Ms. Cui performed the data analysis. All authors contributed to the study design, literature search, data interpretation, and writing.

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Table 1: Baseline characteristics of hospitalized patients with COVID-19.

Characteristics	All (N=247)	Admitted to ICU or died (n=112)	Discharged alive without ICU stay (n=135)	P-value
Demographics				
Age, median (IQR)	61 (50-76)	63.5 (52.5-77.3)	58 (45-72)	0.04
≤40 years, n (%)	35 (14.2)	11 (9.9)	24 (17.8)	0.3
41-50, n (%)	32 (13)	13 (11.6)	19 (14.1)	
51-60, n (%)	54 (21.9)	24 (21.4)	30 (22.2)	
61-70, n (%)	52 (21.1)	28 (25)	24 (17.8)	
>70, n (%)	74 (30)	36 (32.1)	38 (28.1)	
Male, N (%)	143 (57.9)	71 (63.4)	72 (53.3)	
Race/Ethnicity				
White, n (%)	127 (51.4)	57 (50.9)	70 (51.9)	1.0
Black, n (%)	24 (9.7)	10 (8.9)	14 (10.4)	
Hispanic, n (%)	75 (30.4)	34 (30.4)	41 (30.4)	
Asian, n (%)	9 (3.7)	5 (4.5)	4 (3)	
Unavailable, n (%)	12 (4.9)	6 (5.4)	6 (4.5)	
Income				
Median income, \$ (IQR)	66,701 (50336-86601)	64,805 (50336-86601)	66,701 (50336-86562)	0.7
Insurance				0.4
Medicare or Medicare advantage, n (%)	71 (28.7)	39 (34.8)	32 (23.7)	-
Medicaid or MassHealth, n (%)	51 (20.6)	19 (17)	32 (23.7)	-
Dual enrollment, n (%)	30 (12.1)	12 (10.7)	18 (13.3)	-
Private insurance, n (%)	90 (36.4)	40 (35.7)	50 (37)	-

Other, n (%)	5 (2)	2 (1.8)	3 (2.2)	-
Uninsured, n (%)	0 (0)	0 (0)	0 (0)	
Job sector				0.7
Hospitality, n (%)	23 (9.3)	11 (9.8)	12 (8.9)	-
Public safety, n (%)	3 (1.2)	2 (1.8)	1 (0.7)	-
Healthcare workers, n (%)	10 (4)	5 (4.5)	5 (3.7)	-
Retired, n (%)	89 (36)	45 (40.2)	44 (32.6)	-
Public transportation, n (%)	5 (2)	1 (0.9)	4 (3)	-
Unemployed, n (%)	21 (8.5)	10 (8.9)	11 (8.1)	-
Other, n (%)	53 (21.5)	22 (19.6)	31 (23)	-
Unavailable, n (%)	43 (17.4)	16 (14.3)	27 (20)	-
Symptoms				
Time from symptom onset to admission, days median (IQR) (n= 241)	7 days (4-10)	7 days (5-10)	6 days (3-10)	0.4
Cough, n (%)	205 (83)	90 (80.4)	115 (85.2)	0.4
Shortness of breath, n (%)	175 (70.9)	92 (82.1)	83 (61.5)	<0.001
Fever, n (%)	202 (81.8)	94 (83.9)	108 (80)	0.5
Chills, n (%)	76 (30.8)	37 (33)	39 (28.9)	0.5
Rhinorrhea or nasal congestion, n (%)	35 (14.2)	19 (17)	16 (11.9)	0.3
Sore throat, n (%)	66 (26.7)	23 (20.5)	43 (31.9)	0.06
Malaise, n (%)	154 (62.3)	69 (61.6)	85 (63)	0.9
Myalgia, n (%)	107 (43.3)	48 (42.9)	59 (43.7)	0.9
Diarrhea or vomiting, n (%)	89 (36)	40 (35.7)	49 (36.3)	1.0
Headache, n (%)	53 (21.5)	19 (17)	34 (25.2)	0.1
Chest pain, n (%)	42 (17)	20 (17.9)	22 (16.3)	0.9
Palpitations, n (%)	1 (0.4)	0 (0)	1 (0.7)	1.0
Disruption in smell, n (%)	15 (6.1)	4 (3.6)	11 (8.1)	0.2
Disruption in taste, n (%)	24 (9.7)	8 (7.1)	16 (11.9)	0.3
Syncope, n (%)	8 (3.2)	2 (1.8)	6 (4.4)	0.3
Prevalent comorbidities				
Current or former smoker, n (%)	81 (32.8)	36 (32.1)	45 (33.3)	0.9
BMI, median (IQR)	28.5 (25.1-33)	28.3 (25.7-32.3)	28.7 (24.8-33.3)	1.0

Overweight, n (%)	79 (32)	43 (38.4)	36 (26.7)	0.06
Obese, n (%)	108 (43.7)	47 (42)	61 (45.2)	0.7
Overweight or obese, n (%)	187 (75.7)	90 (80.4)	97 (71.9)	0.1
Asthma, n (%)	29 (11.7)	11 (9.8)	18 (13.3)	0.4
COPD, n (%)	22 (8.9)	10 (8.9)	12 (8.9)	1.0
Interstitial lung disease, n (%)	2 (0.8)	1 (0.9)	1 (0.7)	1.0
OSA/OHS, n (%)	23 (9.3)	14 (12.5)	9 (6.7)	0.1
Hypertension, n (%)	128 (51.8)	63 (56.2)	65 (48.1)	0.2
Hyperlipidemia, n (%)	109 (44.1)	55 (49.1)	54 (40)	0.2
Diabetes Mellitus, n (%)	68 (27.5)	36 (32.1)	32 (23.7)	0.1
Known CAD, n (%)	32 (13)	16 (14.3)	16 (11.9)	0.6
Prior MI, n (%)	12 (4.9)	6 (5.4)	6 (4.4)	0.8
Prior revascularization, n (%)	18 (7.3)	10 (8.9)	8 (5.9)	0.5
Heart Failure, n (%)	26 (10.5)	12 (10.7)	14 (10.4)	1.0
PAD, n (%)	7 (2.8)	2 (1.8)	5 (3.7)	0.5
Prior stroke/TIA, n (%)	7 (2.8)	3 (2.7)	4 (3)	1.0
Atrial fibrillation, n (%)	26 (10.5)	16 (14.3)	10 (7.4)	0.1
Liver cirrhosis, n (%)	6 (2.4)	2 (1.8)	4 (3)	0.7
CKD, n (%)	35 (14.2)	11 (9.8)	24 (17.8)	0.1
CKD on dialysis, n (%)	7 (2.8)	5 (4.5)	2 (1.5)	0.2
History of malignancy, n (%)	46 (18.6)	22 (19.6)	24 (17.8)	0.7
Active malignancy, n (%)	22 (8.9)	11 (8.9)	11 (8.1)	1
Prior organ transplant, n (%)	6 (2.4)	4 (3.6)	2 (1.5)	0.4
Rheumatologic or inflammatory disorder requiring immunosuppression, n (%)	18 (7.3)	9 (8)	9 (6.7)	0.8
Home Medications				
Aspirin, n (%)	59 (23.9)	27 (24.1)	32 (23.7)	1.0
Statin, n (%)	107 (43.3)	51 (45.5)	56 (41.5)	0.6
ACEi, n (%)	28 (11.3)	16 (14.3)	12 (8.9)	0.2

ARB, n (%)	31 (12.6)	18 (16.1)	13 (9.6)	0.2
Spironolactone, n (%)	9 (3.6)	4 (3.6)	5 (3.7)	1.0
Sacubitril/valsartan, n (%)	0 (0)	0 (0)	0 (0)	-
Ezetimibe, n (%)	4 (1.6)	2 (1.8)	2 (1.5)	1.0
Beta blockers, n (%)	53 (21.5)	24 (21.4)	29 (21.5)	1.0
NSAIDs, n (%)	29 (11.7)	17 (15.2)	12 (8.9)	0.2
Inhaled bronchodilators, n (%)	46 (18.6)	21 (18.8)	25 (18.5)	1.0
Inhaled corticosteroids, n (%)	35 (14.2)	12 (10.7)	23 (17)	0.2
Oral steroids, n (%)	16 (6.5)	9 (8)	7 (5.2)	0.4
Other immunosuppressive agent, n (%)	25 (10.1)	12 (10.7)	13 (9.6)	0.8

Abbreviations: ACEi, angiotensin-converting-enzyme inhibitors; ARB, angiotensin II receptor blockers; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; ICU, intensive care unit; IQR, interquartile range; MI, myocardial infarction; N, number of patients; NSAIDs, non-steroidal anti-inflammatory drugs; OSA, obstructive sleep apnea; OHS, obesity hypoventilation syndrome; PAD, peripheral artery disease; TIA, transient ischemic attack

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Table 2: Laboratory data on admission

	Reference Range	All (N=247)	Admitted to ICU or died (n=112)	Discharged alive without ICU stay (n=135)	p-value
Laboratory data on admission					
Hemoglobin, g/dL (n=244), median (IQR)	12-16	13.5 (12-14.8)	13.5 (11.8-14.7)	13.6 (12.2-14.9)	0.4
White blood cell count, K/ μ L (n=245), median (IQR)	4.5-11.0	6.4 (4.9-8.8)	7.2 (5-9.2)	6 (4.6-8.3)	0.04
Platelet count, k/ μ L (n=245), median (IQR)	150-400	183 (148-239)	183.5 (136.8-237.5)	183 (153-241)	0.5
Absolute lymphocyte count, cells/ μ L, (n=244), median (IQR)	1,000-4,500	930 (640-1305)	790 (568-1150)	1020 (718-1422)	0.001
Sodium level, mmol/L (n=243), median (IQR)	135-145	136 (133.5-139)	136 (133-138.3)	137 (134-139)	0.2
Potassium, mmol/L (n=243), median (IQR)	3.4 – 5	4 (3.8-4.35)	4.1 (3.8-4.5)	4 (3.8-4.3)	0.1
Lactate, mmol/L (n=169), median (IQR)	0.5 – 2.0	1.3 (1-1.9)	1.4 (1.1-2)	1.2 (1-1.9)	0.05
Peak lactate, mmol/L (n=118), median (IQR)	0.5 – 2.0 mmol/L	1.9 (1.3-2.6)	1.9 (1.5-2.6)	1.4 (1.1-2.2)	0.01
Procalcitonin, ng/ml (n=189), median (IQR)	0.00 - 0.08	0.16 (0.1-0.28)	0.23 (0.13-0.48)	0.12 (0.08-0.19)	<0.001
Peak procalcitonin, ng/ml (n=103), median (IQR)	0.00 - 0.08	0.34 (0.12-1.44)	0.59 (0.26-2.75)	0.12 (0.08-0.18)	<0.001
Urea, mg/dL (n=243), median (IQR)	8 – 25	15 (10-21)	15 (11-22)	14 (10-20)	0.2
Creatinine, mg/dL (n=243), median (IQR)	0.60 – 1.50	0.97 (0.79-1.17)	1.05 (0.8-1.29)	0.94 (0.76-1.12)	0.03
LDH, U/L (n=236), median (IQR)	110 – 210	304.5 (247.3-418.5)	362 (290-507)	276 (220.5-334.5)	<0.001

Peak LDH, U/L (n=215), median (IQR)	110 – 210	397 (294.5-523)	493.5 (365.3-628.3)	325 (258-410)	<0.001
AST, U/L (n=244), median (IQR)	9 – 32	40 (28-59)	46 (33.8-69.8)	35 (24.8-53.3)	<0.001
ALT, U/L (n=244), median (IQR)	7 – 33	28 (20-44.3)	29 (23-50.3)	26.5 (18.8-43)	0.07
Alkaline phosphatase, U/L (n=243), median (IQR)	30 – 100	72 (56-93)	72 (56-93.3)	71 (55.5-92.5)	1
Total bilirubin, (n=242), median (IQR)	0.0 – 1.0	0.5 (0.3-0.6)	0.5 (0.4-0.6)	0.5 (0.3-0.6)	0.3
Direct bilirubin <0.2 mg/dL, n (%)		131/240 (54.6)	57/112 (50.9)	74/128 (57.8)	0.2
Direct bilirubin, mg/dL, median value in those with value ≥0.2 mg/dL, (IQR)	0.0 – 0.4	0.2 (0.2-0.3)	0.2 (0.2-0.3)	0.2 (0.2-0.3)	0.9
Ferritin, ug/L (n=221), median (IQR)	10 – 200	636 (282-1027)	777 (363-1304)	576.5 (241.3-835)	0.006
Peak Ferritin, ug/L (n=203), median (IQR)	10 – 200	958.5 (479.5-1830)	1500.5 (613.8-2812.8)	812 (398.5-1216)	<0.001
Initial CK, U/L (n=223), median (IQR)	40 – 150	117 (66.3-270.5)	152 (83.8-399.8)	90 (55.3-171.8)	<0.001
Peak CK, U/L (n=209), median (IQR)	40 – 150	251 (106.3-617.8)	487 (221-1422)	125 (77.5-272)	<0.001
ESR, mm/h (n=180), median (IQR)	0 – 20	37 (21-56.5)	42 (26-64)	35 (17-53)	0.01
Peak ESR, mm/h, (n=164), median (IQR)	0 – 20	77 (41.8-125)	124 (79-134)	49 (34-77)	<0.001
CRP, mg/L, (n=209), median (IQR)	<8.0	62.8 (20-141.8)	95 (53.5-201.6)	41.2 (14.8-91.4)	<0.001
Peak CRP, mg/L, (n=189), median (IQR)	<8.0	136.3 (2-288)	288 (138.8-326.5)	61.1 (29-141.2)	<0.001
Initial D dimer, ng/ml, (n=229), median (IQR)	< 500	903 (569-1363)	1072 (703-1624.5)	704 (491-1189.5)	<0.001

Peak D dimer, ng/ml, (n=202), median (IQR)	< 500	2313 (1030.5-4000)	3678.5 (1875.8-5696)	1140 (723-2460)	<0.001
Initial hs troponin <6ng/L, n (%)		60/230 (26.1)	18/108 (16.7)	42/122 (34.3)	0.003
Peak hs troponin <6ng/L, n (%)		52/230 (22.6)	13/108 (12)	39/122 (32)	<0.001
Initial hs troponin, ng/L (n=170), median, (IQR)	Male: 0 - 14 Female: 0 - 9	17 (10.3-30.8)	16.5 (11-30.8)	17.5 (9-30.3)	0.3
Peak hs troponin, ng/L (n=178), median, (IQR)	Male: 0 - 14 Female: 0 - 9	20 (11-37.8)	22 (11.5-46.5)	17 (9-32.5)	0.03
Myocardial injury (n=230), N (%)		121/230 (52.6)	71/108 (65.7)	50/122 (41)	<0.001
NT-proBNP, pg/ml (n=136), median (IQR)	Age <50 years: 0-450 Age 50-75 years: 0-900 Age >75 years: 0-1800	227.5 (71.5-1153)	340.5 (104.5-1429.8)	97 (23.8-428.8)	<0.001

Abbreviations: ALT, alanine transaminase; AST, aspartate aminotransferase; CRP, C-reactive protein; CK, creatine kinase; ESR, erythrocyte sedimentation rate; hs troponin, high-sensitivity cardiac troponin; ICU, intensive care unit; IQR, interquartile range; LDH, lactate dehydrogenase; N, number of patients; NT-proBNP, N-terminal pro-b-type natriuretic peptide

1 **Table 3: Treatment strategies**

	Total (N=247)	Admitted to ICU or died (n=112)	Discharged alive without ICU stay (n=135)	p-value
Aspirin, n (%)	53 (21.5)	25 (22.3)	28 (20.7)	0.8
Statin, n (%)	187 (75.7)	90 (80.4)	97 (71.9)	0.1
Newly initiated in hospital, n (%)	85/187 (45.5)	42/90 (46.7)	43/97 (44.3)	0.8
Statin discontinued due to elevated liver function tests, n (%)	27/187 (14.4)	18/90 (20)	9/97 (9.3)	0.06
Statin discontinued due to creatinine kinase elevation, n (%)	28/187 (15)	28/90 (31.1)	0 (0)	<0.001
Discontinued due to creatinine kinase elevation or elevated liver function tests all patients, n (%)	55/187 (29.4)	46/90 (51.1)	9/97 (9.3)	<0.001
Discontinued due to creatinine kinase elevation or elevated liver function tests among patients newly initiated on statin, n (%)	31/85 (36.5)	25/42 (59.5)	6/43 (14)	<0.001
Antibiotics, n (%)	203 (82.2)	110 (98.2)	93 (68.9)	<0.001
Azithromycin, n (%)	182 (73.7)	99 (88.4)	83 (61.5)	<0.001
ACEi/ARB, n (%)	23 (9.3)	7 (6.2)	16 (11.9)	0.2
Discontinued during admission, n (%)	7/23 (30.4)	4/7 (57.1)	3/16 (18.8)	0.1
Venous thromboembolism prophylaxis or therapeutic anticoagulation during admission, n (%)	238 (96.4)	111 (99.1)	127 (94.1)	0.04
Venous thromboembolism prophylaxis, n (%)	215 (87)	98 (87.5)	117 (86.7)	1.0
Enoxaparin, n (%)	178 (72.1)	73 (65.2)	105 (77.8)	0.004
Heparin, n (%)	37 (15)	25 (22.3)	12 (8.9)	0.004
Therapeutic anticoagulation, n (%)	56 (22.7)	45 (40.2)	11 (8.1)	<0.001
Glucocorticoid, n (%)	52 (21.1)	38 (33.9)	14 (10.4)	<0.001
Hydroxychloroquine, n (%)	177 (71.7)	98 (87.5)	79 (58.5)	<0.001

EKG available on drug initiation, n (%)	172/177 (97)	96/98 (98)	76/79 (96.2)	0.7
QTc >500 on initiation, n (%)	4/172 (2.3)	2/96 (2.1)	2/76 (2.6)	1.0
Developed QTc prolongation, n (%)	65/172 (37.8)	52/96 (54.2)	13/76 (17.1)	<0.001
Developed QTc ≥500ms among those with initial QTc <500, n (%)	28/168 (16.7)	26/94 (27.7)	2/74 (2.7)	<0.001
Drug stopped due to QTc prolongation, n (%)	11/177 (6.2)	9/98 (9.2)	2/79 (2.5)	0.1
Developed Torsades de pointes, n (%)	1/177 (0.6)	1/98 (1)	0 (0)	1.0
Tocilizumab, n (%)	12 (4.9)	11 (9.8)	1 (0.7)	0.001
Inhaled nitric oxide, n (%)	21 (8.5)	21 (18.8)	0 (0)	<0.001
Enrolled in clinical trial, n (%)	11/21 (52.4)	11/21 (52.4)	0 (0)	-
Enrolled in Sarilumab clinical trial, n (%)	7 (2.8)	4 (3.6)	3 (2.2)	0.7
Enrolled in Remdesivir clinical trial, n (%)	57 (23.1)	32 (28.6)	25 (18.5)	0.07
IVIg, n (%)	5 (2)	5 (4.5)	0 (0)	0.02

Abbreviations: ACEi, angiotensin-converting-enzyme inhibitors; ARB, angiotensin II receptor blockers; EKG, electrocardiogram; ICU, intensive care unit; IVIG, intravenous immunoglobulin; n=number of patients.

1 **Table 4: Outcomes**

Outcome (N=247)	n (%) or median days (IQR)
Mortality	
All-cause mortality, n (%)	32/247 (13)
Cardiovascular mortality, n (%)	3/247 (1.2)
Median number of days from symptom onset to death (IQR)	19 days (12.5-28)
Median number of days from admission to death (IQR)	12.5 days (8-22)
Cardiovascular events	
Myocardial Infarction, n (%)	12/247 (4.9)
Type 1 myocardial infarction, n (%)	0 (0)
Type 2 myocardial infarction n (%)	12/247 (100)
ST-segment elevation myocardial infarction, n (%)	0 (0)
Coronary angiogram, n (%)	0 (0)
Percutaneous coronary intervention performed, n (%)	0 (0)
Thrombolysis, n (%)	0 (0)
Stoke, n (%)	1/247 (0.4)
Stress cardiomyopathy, n (%)	3/247 (1.2)
Acute Heart failure, n (%)	19/247 (7.7)
Myocarditis, n (%)	1/247 (0.4)
New Atrial fibrillation/flutter, n (%)	21/247 (8.5)
Ventricular tachycardia, n (%)	23/247 (9.3)
Other arrhythmia, n (%)	10/247 (4)
Pericarditis, n (%)	2/247 (0.8)
Coronary vasospasm, n (%)	1/247 (0.4)
Venous thromboembolism, n (%)	12/247 (4.9)
CT pulmonary angiogram or venous doppler ultrasound of extremity performed, n (%)	57/247 (23.1)
Median d dimer in those without venous thromboembolism diagnosed, (IQR)	1595 (996-3971)
Median d dimer in those with diagnosed venous thromboembolism (IQR)	5761 (3374-9955)
CT pulmonary angiogram performed, n (%)	33/247 (13.4)
Pulmonary embolism diagnosed, n (%)	4/33 (12.1)
Median D dimer in those without pulmonary embolism diagnosed (IQR)	1248 (986-3087)
Median D dimer in those with diagnosed pulmonary embolism (IQR)	43993 (23076-64910)
Extremity venous doppler ultrasonography performed, n (%)	38/247 (15.4)
Deep vein thrombosis diagnosed, n (%)	8/38 (21.1)
Median D dimer in those without deep vein thrombosis (IQR)	2236 (1268-5654)
Median D dimer in those with deep vein thrombosis (IQR)	5761 (4039-7430)
Renal outcomes	

Acute renal injury, n (%)	86 (34.8)
Acute renal injury requiring renal replacement therapy, n (%)	17 (6.9)
ICU specific outcomes (n=103)	
Admitted to ICU, n (%)	103/247 (41.7)
Transferred to the ICU from hospital floor service, n (%)	46/190 (24.2)
Median days from symptom onset to ICU admission, days (IQR)	7.5 days (6.25-10)
Median days from admission to ICU transfer (n=46), (IQR)	2 days (1-3.8)
Requirement for vasopressors, n (%)	91/103 (88.3)
Intubated, n (%)	90/103 (87.4)
Extubated, n (%)	71/90 (78.9)
Median number of days from intubation to extubation (IQR)	15 days (8.5-22)
Median number of days from intubation to death, (IQR)	13 (8.3-21.8)
Acute Respiratory Distress Syndrome, n (%)	90/103 (87.4)
Mild, n (%)	10/90 (11.1)
Moderate, n (%)	57/90 (63.3)
Severe, n (%)	23/90 (25.6)
Prone positioning, n (%)	54/103 (52.4)
Paralytic infusion, n (%)	39/103 (37.9)
Extracorporeal membrane oxygenation, n (%)	4/103 (3.9)
Cardiogenic shock, n (%)	4/103 (3.9)
Hemorrhagic shock, n (%)	1/103 (1)
Mixed shock, n (%)	6/103 (5.8)
Percutaneously inserted ventricular assist device, n (%)	1/103 (1)
Intra-aortic balloon pump, n (%)	0/103 (0)
Remains in ICU, n (%)	1/103 (1)
Discharged from ICU alive, n (%)	79/103 (76.7)
Median number of days in ICU for those discharged from ICU alive (IQR)	15 (5-24.5)
Discharged from ICU dead, n (%)	23/103 (22.3)
Median number of days spent in ICU for those discharged from ICU deceased (IQR)	13 (9-22)
Discharge status (N=247)	
Remains admitted, n (%)	2/247 (1)
Discharged alive, n (%)	213/247 (86.2)
Median days from admission to discharge, (IQR)	9 (5-18)
Discharge Location	213 (86.2)
Home, n (%)	143 (67.1)
Skilled nursing facility, n (%)	18 (8.5)
Rehabilitation facility, n (%)	26 (12.2)
Long term acute care facility, n (%)	25 (11.7)
Other, n (%)	1 (0.5)