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Risk Factors for New Neurologic Diagnoses in Hospitalized Patients with COVID-19: A Case-Control Study in New York City

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Take-Home Points:

1. Many patients hospitalized with acute COVID-19 had new neurological diagnoses, most frequently encephalopathy.

2. There was a significant association of new neurological diagnoses with severity of illness, including ICU admission.

3. Those with new neurological diagnoses had a high risk of readmission and mortality during readmission. . Further research is needed to define the impact of neurological diagnoses during acute hospitalization on longitudinal post-COVID-19 related symptoms including neurocognitive impairment.

Abstract:

Background/Objective: There have been numerous reports of neurological manifestations identified in hospitalized patients infected with SARS-CoV-2, the virus that causes COVID-19. Here, we identify the spectrum of associated neurological symptoms and diagnoses, define the time course of their development, examine readmission rates and mortality risk post-hospitalization in a multiethnic urban cohort.

Methods: We identify the occurrence of new neurological diagnoses among patients with laboratory-confirmed SARS-CoV-2 infection in New York City. A retrospective cohort study was performed of 532 cases (hospitalized patients with new neurological diagnoses within 6 weeks of positive SARS-CoV-2 laboratory results between March 1, 2020 and August 31, 2020). We compare demographic and clinical features of the 532 cases to 532 COVID-19 positive controls without neurological diagnoses in a case-control study with 1 to 1 matching; and

examine hospital-related data and outcomes of death and readmission up to 6 months after acute hospitalization in a secondary case-only analysis.

Results: Among the 532 cases, the most common new neurological diagnoses included encephalopathy (478, 89.8%), stroke (66, 12.4%), and seizures (38, 7.1%). In the case-control study, cases were more likely than controls to be male (58.6% vs. 52.8%, p=0.05), have baseline neurological comorbidities (36.3% vs. 13.0%, p<0.0001) and be treated in an intensive care unit (ICU) (62.0% vs. 9.6%, $p < 0.0001$). Of the 394 (74.1%) cases that survived the acute hospitalization, more than half (220/394, 55.8%) were readmitted within 6 months, with a mortality rate of 23.2% during readmission.

Conclusion: Many patients hospitalized with SARS-CoV-2 have new neurological diagnoses, with significant morbidity and mortality post-discharge. Further research is needed to define the impact of neurological diagnoses during acute hospitalization on longitudinal post-COVID-19 related symptoms including neurocognitive impairment.

INTRODUCTION

Neurological symptoms and conditions are seen across the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) disease continuum including the early prodromal phase, acute phase, and are being increasingly reported in the post-infectious period. [1] Estimates of the impact of SARS-CoV-2 on those with underlying neurological conditions as well as those who develop new neurological manifestations in the context of acute SARS-CoV-2 infection is significant though has varied across studies. [2-5] Differences in methodology including case definitions and case ascertainment have contributed to variable reporting of hospital-based data on neurological conditions. [6, 7]. As worldwide coronavirus disease 2019 (COVID-19) cases

continue to rise and novel variants emerge, a more comprehensive clinical understanding of short and long-term complications remains crucial. In this study, we identify the occurrence of neurological diagnoses among patients with laboratory-confirmed SARS-CoV-2 infection in New York City comprised of a large proportion of medically underserved persons, which was the epicenter of the first surge of the COVID-19 pandemic in the United States. We compare demographic and clinical features of COVID-19 patients with neurological diagnoses during hospitalization to those without neurological diagnoses in a retrospective case-control study; and examine hospital-related data and outcomes of death and readmission up to 6 months after acute hospitalization among cases alone.

METHODS

Neurological COVID-19 Patient Identification

We retrospectively reviewed electronic medical records (EMR) of patients hospitalized with COVID-19 during March 1, 2020 and August 30, 2020 at Columbia University Irving Medical Center-New York Presbyterian Hospital (CUIMC/NYP) in New York City, encompassing Milstein Hospital, Morgan Stanley Children's Hospital of New York (CHONY), and Allen Hospital. Only laboratory confirmed SARS-CoV-2 infected individuals, defined by a positive nasopharyngeal swab SARS-CoV-2 reverse transcriptase polymerase chain reaction (RT-PCR) test result were included in the study. Clinical data were collected both through manual EMR review and data extracted from the CUIMC COVID-CARES database, which is a hospital system wide database of all patients tested for COVID-19, including hospitalized patients with positive SARS-CoV-2 RT-PCR results admitted to CUIMC-NYP, Allen-NYP, and CHONY-NYP.

Cases were defined as hospitalized patients who developed new neurological diagnoses within six weeks of their first positive SARS-CoV-2 rt-PCR result. To identify cases, 2318 patients from all neurology services were reviewed for new-onset neurological signs / symptoms from the vascular and general neurology units, neurological intensive care unit (NICU), neurology consult lists, and epilepsy monitoring unit. Additionally, patients with any neuroimaging, electroencephalogram (EEG), and/or lumbar puncture (LP) results were reviewed. Altogether, 574 patients with new-onset neurological signs, symptoms, and diagnoses were identified [Figure 1]. Additionally, every 10th patient among 3635 patients from the COVID-CARES database was reviewed for specified new neurologic diagnoses to address selection bias for those with severe neurological conditions who are typically managed by neurology services. A total of seventy-five additional patients with neurological signs, symptoms and diagnoses were identified from the COVID-CARES database [Figure 1]. Continuous EEG (cEEG) data were categorized by the presence of sporadic epileptiform discharges, periodic epileptiform discharges, electrographic seizures, electroclinical seizures, upon review by epilepsy specialists (MB and BW). All neurological diagnoses were made by the clinical team based upon established clinical practice parameters. All neurological diagnoses represented in these cases were based on diagnosis by the clinical team, and included utilizing established criteria for diagnosis of encephalopathy: disturbance in attention (reduced ability to direct, focus, sustain, and shift attention) and awareness (reduced orientation to environment) AND disturbance develops over a short period of time (hours to days), represents an acute change from baseline attention and awareness, and tends to fluctuate in severity during the course of a day AND an additional disturbance in cognition (memory deficit, disorientation, language, visuospatial ability, perception).[8] From a total of 649 identified neurological cases, 31 patients with only

SARS-CoV-2 serology positivity and 86 patients who presented with neurological signs and symptoms but were discharged without formal neurological diagnoses were excluded, leaving 532 that met the case definition.

Descriptive Case Analysis

We analyzed the distribution and timing of neurological diagnoses, clinical characteristics, and outcome measures. Neurologic diagnoses and presenting COVID-19 symptoms were stratified by age categories. Timing of neurologic diagnosis was calculated as the number of days between neurologic diagnosis and first RT-PCR positive SARS-CoV-2 test result. Hospital related data including length of stay (LOS), intensive care unit (ICU) admission, ICU LOS, and oxygen requirement; outcome measures of limiting treatments to comfort measures only, hospice admission, mortality during acute hospitalization, and readmission to an NYP hospital within 6 months of COVID-19 hospitalization were further described. Data analysis was performed using SAS v9.4 (SAS Institute, Cary NC).

Case-Control Population

A case-control study was conducted to assess differences in COVID-19 patients with and without neurologic diagnoses. *Controls* were defined as patients hospitalized with laboratory - confirmed SARS-CoV-2 infection by RT-PCR and without new neurologic diagnoses or neurologic signs/symptoms as listed in Table 1. Potential controls were identified from the COVID-CARES database and matched one-to-one to cases based on calendar time (+/-5 days of hospital admission date). Descriptive analyses of sociodemographic information and prior medical history were performed to compare cases and controls. Basic frequencies were calculated, and comparisons of categorical data were made using Pearson's Chi-square test and

Fisher's exact test as appropriate. Two-sample student's t-test was used to compare continuous variables and the Wilcoxon rank sum test was used when sample size was small (n<5). Unmatched logistic regression models were used to assess differences in prior medical history between cases and controls in adjusted models, controlling for age as a continuous variable and sex. Data analysis was performed using SAS v9.4 (SAS Institute, Cary, NC).

Standard Protocol Approvals, Registrations, and Patient Consents

This activity was reviewed by CDC and was conducted in a manner consistent with applicable federal law and CDC policy (45 C.F.R. part 46.102(l)(2), 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.) as a public health non-research project. This study received approval from CUIMC institutional review board (IRB) with a waiver of written informed consent for retrospective analysis.

Data Availability

Data supporting the findings of this study are available from the corresponding author (KT) upon request. All supplementary data will be made available upon request with further anonymized data available to qualified investigators upon request to the corresponding author.

RESULTS

Description of Cases:

Of the 2681 patients (2318 from neurological services and 363 from the CARES database) reviewed, 532 (20.4%) met the case definition of laboratory confirmed acute SARS-CoV-2 infection and new neurologic diagnoses at hospital presentation and/or during hospitalization [Figure 1]. The mean (standard deviation, SD) age was 65 years (17.8), with 303 (57.0%) 65

years and older. Three-hundred and twelve (58.6%) were male, and 242 (45.5%) self-identified as Hispanic/Latino ethnicity. One hundred forty-one (26.5%) self-identified as White, 112 (21.1%) as Black, 13 (2.4%) as Asian, and 154 (28.9%) as other/Multiracial. [Table 1]. There were no significant differences in age between Hispanic/Latino and non-Hispanic/Latino cases. No significant differences in death, hospice, readmission, or death during re-admission between the two groups [Table e-6].

Encephalopathy was the most common new neurological diagnosis (478, 89.8%) followed by ischemic stroke (66, 12.4%), seizures (38, 7.1%), intracranial hemorrhage (ICH) (33, 6.2%), critical illness myopathy (19, 3.6%), critical illness neuropathy (9, 1.7%), and posterior reversible encephalopathy syndrome (PRES) (3, 0.6%). [Table 2] Cases with encephalopathy, were significantly more likely to be of older age ($p=0.02$) and have pre-existing neurological disorders (181, 37.9% v. 12, 22.2%; $p=0.02$) when compared to cases without encephalopathy [Table e-1]. Seizure diagnosis was significantly associated with age ($p<.0001$), with the majority of seizures (23/38, 60.5%) occurring in age groups under 65 years of age [Table 2]. While not significant, both ischemic stroke (25/66, 17.4%) and intracranial hemorrhage (ICH) (14/33, 9.7%) were more prevalent in patients aged 50-64 years when compared to other age groups [Table 2]. Common neurologic sign/symptoms reported include confusion (257, 48.3%), reduced consciousness (125, 23.5%), and psychiatric manifestations defined as new symptoms of depressed mood, anxiety and/or mania (53, 10%) [Table e-2].

A new neurological diagnosis was established on initial hospital presentation in 29% (110/376 with diagnosis dates noted) of cases: 75/297 (25.3%) cases of encephalopathy, 15/53 (28.3%) cases of ischemic stroke and 13/31 (41.9%) cases of seizure [Figure 2]. Cases, on

average, had a neurologic diagnosis 10 days after the first positive SARS-CoV-2 RT-PCR test (median = 4.9 days, inter-quartile range = -0.5 – 19.2 days, range: -32.1 – 69.5 days) [Figure 2].

The average length of hospital stay (LOHS) was 30.2 days (SD=32.2) for cases, with 330 (62%) patients admitted to the ICU [Figure e-1A]. The average LOS in the ICU was 26 days; 237 cases (44.5%) stayed in the ICU for more than 10 days, of which 22 (9.3%) cases had ICU stays of more than 60 days. [Figure e-1B]. Two hundred and seventy-eight (52.3%) individuals were intubated, 104 (19.5%) received renal replacement therapy (RRT), and 6 (1.1%) were placed on extracorporeal membrane oxygenation (ECMO) [Table 3]. Fifteen percent (80/532) of cases had thrombotic complications including 60 (11.1%) with deep vein thromboses (DVT) and 21 (3.9%) with pulmonary embolism (PE) [Table e-4]. Outcome measures of cases with neurologic diagnoses included provision of comfort care only (111, 20.9%), death during initial hospitalization (138, 25.9%), readmission to an NYP hospital within 6 months (220, 55.8%), and death during hospital re-admission (51, 9.6%) [Table 3].

Case-Control Study

There were 532 controls matched to cases based on hospitalization date. Cases with new neurological diagnoses were older compared to controls (mean 65.0 years [SD: 17.8] vs. 58.7 years [SD: 21.3]; $p < 0.0001$) with more than half of the cases (303, 57.0%) 65 years and older [Table 1]. Cases were more likely to be male (58.6% vs. 52.8%, $p < 0.05$) and have a past medical history of hypertension (66.7% vs. 48.7%), hyperlipidemia (33.1% vs. 23.1%), diabetes mellitus type I or II (43.6% vs. 32.0%), chronic kidney disease (13.9% vs. 7.5%), dementia (14.5% vs. 4.3%), stroke (13% vs. 3.6%), or seizures (8.6% vs. 1.7%) when compared to controls ($p < 0.0001$) [Table e-3]. Controls were more likely to have no prior medical history than

cases (20.7% vs. 7.0%, p <0.0001) and cases were more likely to be admitted to the ICU when compared to controls (62.0% vs. 9.6%, p <0.0001) [Table e-3].

When controlling for age and sex in an adjusted model, preexisting neurological conditions which included a history of seizure (adjusted OR 6.23; 95% CI 2.97, 13.09; $p < 0.0001$), stroke (adjusted OR 3.48; 95% CI 2.05, 5.90; $p < 0.0001$) or dementia (adjusted OR 3.15; 95% CI 1.90, 5.23; $p < 0.0001$) remained more prevalent in cases compared to controls as did comorbidities of hypertension (adjusted OR 1.77; 95% CI 1.33, 2.34; $p < 0.0001$), hyperlipidemia (adjusted OR 1.37; 95% CI 1.03, 1.82; $p < 0.0001$), diabetes (adjusted OR 1.45; 95% CI 1.12, 1.88; $p < 0.0001$), and renal disease (adjusted OR 1.48; 95% CI 1.05, 2.09; $p < 0.0001$) [Figure e-2].

DISCUSSION

In our hospitalized COVID-19 population in New York City, new neurological diagnoses were commonly found. Our study documents neurologic presentations and manifestations among minority populations impacted significantly by the COVID-19 pandemic in the U.S. A significant portion of our hospitalized cohort were critically ill and died or were made comfort care during hospitalization. In a prior NYC-based study performed by Thompson et al., the highest incidence, hospitalization rates, and mortality were among Black/African American and Hispanic/Latino persons, as well as those who were living in neighborhoods with high poverty including our local Northern Manhattan community, aged ≥75 years, and with underlying medical conditions.[9]

Our study found that COVID-19 infected patients with new neurologic diagnoses had substantial rates of readmission and death up to 6 months after discharge. Overall, early data from other studies have shown that readmission and mortality among COVID-19 survivors is common. [10, 11] In a national cohort of patients in the Veterans Administration (VA) system, 27% of survivors of COVID-19 hospitalization were readmitted or died by 60 days after discharge and another CDC based study among 106,543 (85%) surviving patients, 9% (9,504) were readmitted to the same hospital within 2 months of discharge through August 2020. [10, 11] Few studies have assessed readmission and mortality after acute hospitalization in COVID-19 patients with neurological diagnoses. One study published in a post-hospitalized cohort showed that patients with neurological complications due to acute COVID-19 infection had worse 6-month Modified Rankin Scale score (median score 4 vs. 3 among controls, adjusted OR 1.98, 95%CI 1.23-3.48, p = 0.02), poorer activities of daily living (aOR 0.38, 95%CI 0.29-0.74, p = 0.01), and a lower likelihood of returning to work than those hospitalized with acute COVID-19 without neurological complications (41% versus 64%, p = 0.04). [12]

Other studies have found a similar association between neurological diagnosis and severity of COVID-19 infection, particularly amongst older adults over 60 years of age. [13] The relationship between COVID-19 severity and neurological manifestations is likely bidirectional, as severely ill patients seem to be more likely to develop neurological complications related to severe systemic illness effects and those predisposed with underlying neurological may be predisposed to more severe COVID-19 illness. Similar to other hospital-based populations, the most commonly identified neurological diagnoses included encephalopathy followed by ischemic stroke.[14] Many neurological conditions during acute COVID-19 are seen in other systemic infectious diseases, including sepsis-associated encephalopathy, which is seen in up to

70% of patients, and in COVID-19 acute respiratory distress syndrome (ARDS), which is associated with significant neuro-disability both in the acute and post-acute period. [15] Consistent with other hospital-based studies, COVID-19 patients with neurological diagnoses, most commonly encephalopathy, were older with more than half of the cases 65 years and older.[4] Delirium is significantly more common in older people who have COVID-19, with data from a recent meta-analysis and systematic review demonstrating 1 in 3 hospitalized older COVID-19 patients are affected (pooled prevalence 34%), compared with 5% in young adults aged 18-34 years and 12% for all ages.[13] Importantly, delirium in older hospitalized patients has previously been demonstrated to be an independent risk factor for mortality and cognitive impairment. [6] Unique to our cohort, we identified that approximately one third of neurological conditions, including encephalopathy, stroke and new onset seizures, were diagnosed at the time of initial hospital presentation, emphasizing that neurological conditions are commonly presenting features in the acute phase of COVID-19 infection and may mask systemic symptoms.

Careful review of the EMR did not reveal any cases of meningoencephalitis and while there has been conflicting evidence around whether SARS-CoV-2 may have neurotropic potential, data from several neuropathological studies suggests this to be less likely [16-20] Whether novel variants may lead to varied neurological presentations and possibly alter the viruses neuroinvasive potential requires further analysis, as our data captured cases from the first surge of the pandemic.

This study has several limitations. We focus our study on hospitalized COVID-19 patients in one hospital system, and do not identify neurological manifestations in those with asymptomatic or mild disease. We conducted our study during the first major surge of the COVID-19 pandemic when SARS-CoV-2 RT-PCR testing was not readily available at times.

Our demographic data including race and ethnicity relied on chart review data, which was not available in many charts. Given the retrospective nature of our study, we relied on chart review to identify clinical data, and thus there is likely an underreporting of neurological symptoms, signs and conditions. To define new neurological diagnoses, we relied on diagnoses by clinical teams, often lacking formal neurologic consultation, though we did attempt to utilize ancillary studies (neuroimaging, EEG, LP results) to confirm clinical diagnosis [Table e-5]. During our first surge of the pandemic, many neurological assessments were performed via phone/video consultation limiting the interpretation of findings and many patients presented in acute respiratory distress and thus, there is limited data with regards to early prodromal symptoms/signs. Thus, there is likely a significant underrepresentation of neurological diagnoses which would be obtained by a detailed bedside neurological evaluations, including peripheral neuropathy and myopathies. Strengths of our study include the use of cases and controls with definitive SARS-CoV-2 by laboratory testing. Although we included some patients that were drawn from services other than neurology in our sample, most came from the neurology services, and so our findings may not apply or be generalizable to other patient groups. We evaluated a large number of patients in a multi-ethnic population and performed detailed and extensive chart reviews to obtain data. We evaluate 6-month-posthospitalization-related data including readmission and mortality-related data. Due to our reliance on EMR data though, we were only able to capture those who were readmitted to our NYP hospital system, thus likely underestimating readmission and mortality rates in the early post-SARS-CoV-2 period.

In conclusion, in this urban study with a substantial number of Hispanic/Latino individuals hospitalized with laboratory confirmed SARS-CoV-2 infection, we found that many had new neurological diagnoses, most frequently encephalopathy. There was a significant

association of new neurological diagnoses with ICU admission. Concerningly, those with new neurological diagnoses had a high risk of readmission and mortality during readmission. Quantifying the burden of neurological events during the acute phase of illness will shed light on potential risk factors and mechanisms of post-COVID-19 neuropsychiatric conditions increasingly reported in survivors. [2, 21-24] Several questions remain with regards to the implications of the timing and severity of neurological manifestations on post-acute COVID-19 recovery. Well-designed cohorts in the acute COVID-19 period are needed to define risk factors associated with poor outcomes in the post hospitalization period, especially amongst multiethnic cohorts who were impacted significantly by the pandemic.

TABLES AND FIGURES

Table 1. Demographic characteristics of hospitalized COVID-19 patients with and without new neurologic diagnoses.

	Cases* (n=532)		**Controls^ (n=532)**		**X^2 p-value†**
Age: Mean (SD)	65.0 years (17.8)		58.7 years (21.3)		<0.0001
Age category					
< 18 years	15	2.8%	19	3.6%	<0.0001
18-49	69	13.0%	143	26.9%	
50-64	144	27.1%	131	24.6%	
65-79	203	38.2%	150	28.2%	
80+	100	18.8%	89	16.7%	
Unknown	*1*	0.2%	*0*	0.0%	
Sex					
Male	312	58.6%	281	52.8%	0.05
Female	219	41.2%	251	47.2%	
Unknown	*1*	*0.2%*	*0*	*0.0%*	
Ethnicity					
Hispanic/Latino	242	45.5%	280	52.6%	0.002
Non-Hispanic/Latino	174	32.7%	127	23.9%	
Other	11	2.1%	20	3.8%	
Declined/Unknown	105	19.7%	105	19.7%	
Race					
White	141	26.5%	122	22.9%	0.36
Black	112	21.1%	99	18.6%	

Asian	13	2.4%	12	2.3%	
Other / Multiracial	154	28.9%	170	32.0%	
Declined/Unknown	112	21.1%	129	24.2%	
Past Medical History					
None	37	7.0%	110	20.7%	<.0001
Chronic lung disease	96	18.0%	86	16.2%	0.42
Cardiac disease	383	72.0%	296	55.6%	<.0001
Diabetes mellitus	232	43.6%	170	32.0%	<.0001
History of neurologic disease	193	36.3%	69	13.0%	<.0001
Renal disease	99	18.6%	64	12.0%	0.003
Liver disease	18	3.4%	16	3.0%	0.73
Immune disorder	63	11.8%	58	10.9%	0.63
Immunocompromising medications	31	5.8%	15	2.8%	0.02
Pregnant	1	0.5%	32	12.8%	<0.0001
ICU admission	330	62.0%	51	9.6%	<.0001

† Ch-square p-value

*Cases defined as patients hospitalized between March – August 2020 in the New York Presbyterian system, who are diagnosed with a new neurological condition within 6 weeks of RT-PCR positivity.

^Controls defined as patients hospitalized between March – August 2020 in the New York Presbyterian system who are SARS-CoV-2 RT-PCR+ with no new neurological diagnosis within 6 weeks of RT-PCR positivity.

Table 2. New neurological diagnosis for hospitalized COVID-19 patients

Neurologic Diagnosis+	**All Cases (n=532)‡**		**< 18 years (n=15)**		**18 - 49 years (n=69)**		**50 - 64 years (n=144)**		**65 - 79 years (n=203)**		**80+ years (n=100)**		**X^2 p-value†**
	n	%	n	%	n	%	n	%	n	%	n	%	Na
Encephalopathy	478	89.8%	11	73.3%	59	85.5%	127	88.2%	184	90.6%	97	97.0%	0.02
Ischemic stroke	66	12.4%	1	6.7%	6	8.7%	25	17.4%	23	11.3%	10	10.0%	0.25
Seizures	38	7.1%	7	46.7%	5	7.2%	11	7.6%	12	5.9%	3	3.0%	<.0001
Intracranial hemorrhage	33	6.2%	1	6.7%	3	4.3%	14	9.7%	12	5.9%	2	2.0%	0.15
Critical illness myopathy	19	3.6%	0	0.0%	5	7.2%	8	5.6%	6	3.0%	0	0.0%	0.05*
Critical illness neuropathy	9	1.7%	0	0.0%	2	2.9%	4	2.8%	3	1.5%	0	0.0%	0.43*
Posterior Reversible Encephalopathy Syndrome (PRES)	3	0.6%	0	0.0%	2	2.9%	1	0.7%	0	0.0%	0	0.0%	0.1*
Acute Disseminated Encephalomyelitis (ADEM)	1	0.2%	0	0.0%	1	1.5%	0	0.0%	0	0.0%	0	0.0%	0.16*
Mononeuritis multiplex	1	0.2%	0	0.0%	0	0.0%	0	0.0%	1	0.5%	0	0.0%	1*
Meralgia paresthetica	1	0.2%	0	0.0%	1	1.5%	0	0.0%	0	0.0%	0	0.0%	0.16*
Myelitis	1	0.2%	0	0.0%	1	1.5%	0	0.0%	0	0.0%	0	0.0%	0.16*

† Chi-square p-value with 4 degrees of freedom

*Exact test

‡ 1 case was missing age information, and not included in age stratified table

+clinical diagnoses established by EMR search term review for diagnoses in chart.

Table 3. Clinical characteristics and outcomes of hospitalized COVID-19 patients with new neurologic diagnoses

	Cases (n=532)	
Overall	**n**	**%**
Highest oxygen requirement		
Room air	46	8.6%
Nasal cannula	66	12.4%
Non-rebreather mask	79	14.8%
Non-invasive ventilation	6	1.1%
Intubation	278	52.3%
Outcomes		
Renal replacement	104	19.5%
Extracorporeal membrane oxygenation (ECMO)	6	1.1%
Comfort care	111	20.9%
Do not resuscitate/Do not intubate	250	47.0%
Discharge Status		
Survived	394	74.1%
Hospice	31	5.8%
Death	138	26.0%
Post-discharge Status		
Survived (including in hospice)	n=394	
Re-admission* within 6 months	220 / 394	55.8%
Death (after re-admission)	51 / 220	23.2%

*Readmission to Columbia University Irving Medical Center (CUIMC), Children's Hospital of New York (CHONY) or Allen Hospital in New York Presbyterian (NYP) system

Figure Legends

Figure 1: Case inclusion. Central boxes with dashed lines represent sources from which cases and controls were identified, including all Neurology units and the COVID-CARES database established at CUIMC/NYP. The workflow on the left details exclusion process for cases; the right side details exclusion process for controls. Bold outlined boxes indicate final sample size for cases and controls.

*Abbreviations: Neurological Intensive Care Unit (NICU), Epilepsy Monitoring Unit (EMU), continuous electroencephalography (cEEG), lumbar puncture (LP), Coronavirus disease 2019 (COVID-19), severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), reverse transcriptase polymerase chain reaction (RT-PCR)
†COVID-CARES: Comprehensive database of COVID-19 infectious cases at CUIMC

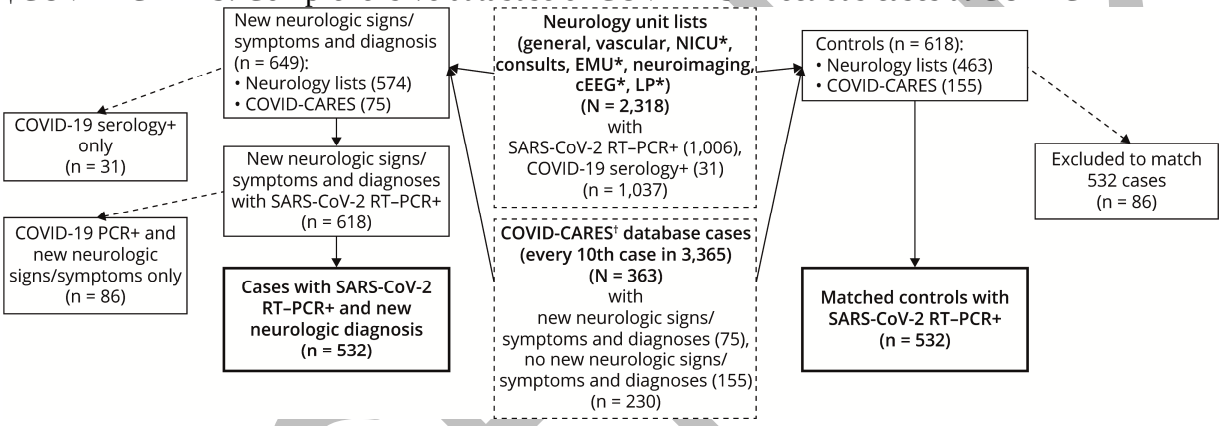
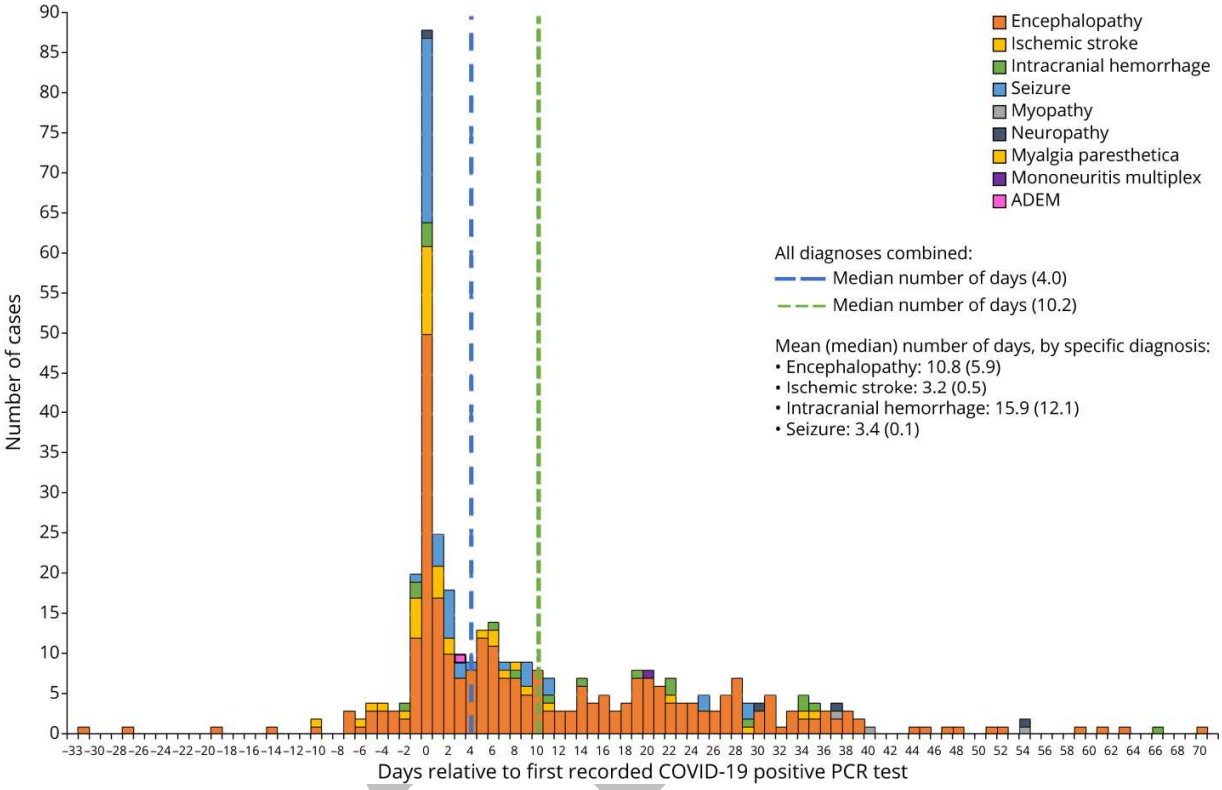


Figure 2. Time of first recorded COVID rt-PCR positive test to first neurologic diagnosis. Cases with neurological diagnoses established on the same day of their first positive COVID PCR test (usually coinciding with day of presentation to hospital) are indicated by the bar at zero days. Cases with established primary neurological diagnoses before their first COVID PCR positivity result are represented by units to the left of zero days. Cases with established primary neurological diagnoses after their first COVID positive PCR test are indicated to the right of zero days. All cases are color coded by diagnosis. The blue and green dashed lines indicate median and mean number of days between first COVID positive PCR test and primary neurological diagnosis, respectively.



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