Short Term and Long Term Implications of Covid-19 among Veterans at the New York VA HealthCare System Hospital, USA

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Abstract: **Background:** Covid-19 is a pro-inflammatory condition that can affect all organs in the body along with impact on behavioral health. In our study, we investigated long term effects of SARS-COV 2 infection in patients admitted at Veteran Hospital in Brooklyn NY from March 3rd, 2020 to May 31st, 2020. Patients were followed at different time intervals to evaluate the clinical and behavioral outcomes after SARS-COV 2 infection. **Methods:** We performed a retrospective study of SARS-COV 2 patients that were admitted in Brooklyn VA Harbor hospital between March-May 2020. Patients were tested with nasopharyngeal swab and only patients who tested positive with RT-PCR were included in the study. Patients were called via telehealth services to evaluate for new or persistent symptoms, re-hospitalizations and deaths post discharge from hospital. We followed these patients at 30, 60, 90 and 180 days after discharge to investigate their clinical as well as behavioral outcomes. **Results:** In a period of March, 2020 to end of May, 2020, 400 patients were diagnosed with COVID-19 in hospital. All 400 patients were included in the analysis. Almost half the patients were African Americans (n =201, 50.2%). The rest of the participants were predominantly white (n =114, 28.5%), and Hispanic (n =71, 17.8%). The sample was predominantly male (n = 375, 93.7%). The average age of the sample was 67.8 years (SD = 14.16). Analysis of post-COVID symptoms revealed that 30 days after COVID, the most common symptoms by organ functioning type was associated with respiratory function (n = 124, 31.0%). For all other post evaluation dates, behavioral symptoms were the most common (60: n = 29, 7.2%; 90 n = 22, 5.5%; 180: n = 27, 6.8%). **Conclusions:** Post 30 days of onset of COVID 19 symptoms, majority of patients still had persistent respiratory system dysfunction, such as cough, shortness of breath, dyspnea on exertion. 89 patients died due to severe COVID during the 30-day period. Upon following the patients for 6 months, we observed that majority of the patients had new onset or ongoing mental/behavioral problems, such as anxiety, depression, nosophobia, followed by respiratory symptoms.

Keywords: COVID-19, Persistent symptoms, Primary endpoints, Secondary endpoints, Follow up.

INTRODUCTION

In December 2019, China reported an outbreak of pneumonia of unknown causes in Wuhan, the capital city of Hubei province. Most of the early cases were epidemiologically linked to the Huanan seafood wholesale market where aquatic animals and live animals were sold [Li, Q. *et al*., 2020]. Viral genomic sequencing of lower respiratory tract samples of patients affected by disease, showed more than 85% identity with a bat SARS-like CoV, the isolated virus was named 2019-nCoV [Zhu, N. *et al*., 2020]. On February 11, 2020 the World Health Organization announced an official name for the disease that is causing the 2019 novel coronavirus outbreak, first identified in Wuhan China. The new name of this disease was coronavirus disease 2019, abbreviated as COVID-19. On January 21st the Centers for Disease Control and Prevention (CDC) confirmed the first case of 2019 Novel Coronavirus (2019-nCoV) in the United States in the state of Washington. On March 11 the World Health Organization (WHO) declared COVID-19 as a pandemic [AJMC Staff, 2021]. As of today, 164 million cases of COVID-19 cases and 3.4 million deaths are reported.

COVID-19 is primarily considered a viral respiratory illness as its causative agent, SARS-CoV-2, predominantly targets the respiratory system. The clinical spectrum of COVID-19 varies from asymptomatic or paucisymptomatic forms to clinical illness characterized by acute respiratory failure requiring mechanical ventilation, septic shock, and multiple organ failure [Cascella, M. *et al*., 2021]. It is estimated that 17.9% to 33.3% of infected patients will remain asymptomatic which contributes to less than one third of the total cases [Mizumoto, K. *et al*., 2020]. Meanwhile, majority of symptomatic patients present with fever, cough, muscle aches, headache, and loss of smell or taste [Stokes, E.K. *et al*., 2020].

Individuals of all ages are at risk of contracting this infection and development of severe disease. However, patients aged ≥60 years and patients with underlying medical comorbidities (obesity, cardiovascular disease, chronic kidney disease, diabetes, chronic lung disease, smoking, cancer, solid organ or hematopoietic stem cell transplant patients) have an increased risk of developing severe COVID-19 infection [Cascella, M. *et al*.,

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2021]. The percentage of COVID-19 patients requiring hospitalization is six times higher in those with preexisting medical conditions than those without medical conditions (45.4% vs. 7.6%) based on an analysis of confirmed cases reported to the CDC during January 22 to May 30, 2020[6]. Also, multiple studies reported discrepancy of morbidity and mortality rates among patients of different ethnic groups. This was observed on a CDC analysis of hospitalizations from a large administrative database that included approximately 300,000 COVID-19 patients from March 2020 to December 2020 [Romano, S.D. *et al*., 2021].

COVID-19 mainly targets respiratory system leading to development of respiratory failure secondary to acute respiratory distress syndrome [Wang, D. *et al*., 2020; Richardson, S. *et al*., 2020; Petrilli, C.M. *et al*., 2020]. However, it can also cause several other complications involving cardiovascular, gastrointestinal, renal, central nervous system disease, thromboembolic events, and secondary infections [Wang, D. *et al*., 2020; Chen, T. *et al*., 2020; Arentz, M. *et al*., 2020; Liotta, E.M. *et al*., 2020; Klok, F.A. *et al*., 2020; Moll, M. *et al*., 2020; Rawson, T.M. *et al*., 2020]. SARS-CoV-2 induced organ dysfunction can be explained by either one or a combination of the proposed mechanisms such as direct viral toxicity, ischemic injury caused by vasculitis, thrombosis, or thrombo-inflammation, immune dysregulation, and renin-angiotensin-aldosterone system (RAAS) dysregulation [Coopersmith, C.M. *et al*., 2021].

More recently, data have emerged that some patients continue to experience symptoms related to COVID-19 after the acute phase of infection. Preliminary reports indicate some patients may develop a so-called "post-acute COVID-19 syndrome," in which they experience persistent symptoms after recovering from their initial illness. The time to recovery is highly variable and depends on age and pre-existing comorbidities in addition to illness severity. Individuals with mild infection are expected to recover relatively quickly whereas many individuals with severe disease have a longer time to recovery.

In this report we will review, analyze, and compare among patients with different age, gender, ethnic groups and comorbidities. We will also evaluate the persistence of symptoms in patients after acute COVID-19 illness at 30, 60, 90 and 180 days.

MATERIALS AND METHODS
Study Design and Participants
In this study we included 400 patients diagnosed with COVID 19 illness at Brooklyn VA Harbor hospital between March 3 to May 31, 2020. Patients with mild symptoms were discharged home from ER, but patients with moderate and severe disease were admitted to the hospital for observation and treatment. Mild symptoms were described as fever, chills, myalgia, rhinorrhea, ageusia with oxygen saturation > 94% on room air and hemodynamic stability. Moderate and severe symptoms were described as having new neurological abnormalities including altered mental status, acute stroke, new onset arrhythmias, acute myocardial infarction, diabetic ketoacidosis, sepsis, acute respiratory distress with saturation 94% and below, requiring oxygen supplementation [Gandhi, R.T. *et al*., 2020]. Admissions were based on severity of symptoms or due to multiple comorbidities, requiring close monitoring. Patients received standard therapy for COVID 19 illness that included Hydroxychloroquine, Azithromycin, Steroids and Tocilizumab. SARS-COV2 treatment was upgraded as per changes in guidelines during the period of March-April 2020. The admitted patients also received supportive measures like oxygen supplementation via nasal cannula, oxygen masks or mechanical ventilation, renal replacement therapy such as CVVH or dialysis, blood and blood product transfusion, anticoagulation, anti-arrhythmic, and management of ARDS. These patients were discharged based on hemodynamic stability and no SARS-COV2 testing was repeated at discharge.

Following discharge, telehealth was set up at Brooklyn VA Harbor, which included primary care physicians, nursing staff and specialties as per patients' needs. Patients with new cardiac arrhythmias, acute kidney injury, new onset seizures, increased oxygen requirements were followed up by cardiologist, nephrologist, neurologist, pulmonologist, respectively. These services were provided to all patients discharged from the hospital ranging from mild to severe symptoms. Patients were called monthly but were sometimes called more frequently based on the severity of their symptoms. A significant number of patients also had PTSD and depression due to their occupational risks and all of them were monitored closely by behavioral health programs via telehealth by having individual or group sessions with providers.

Data Collection

Retrospective study was performed in patients presenting at Brooklyn VA Harbor hospital between March- May 2020. A subsequent review of the electronic medical record was performed for each patient to obtain demographic, clinical, and laboratory information. Demographic data included age, race and gender. We recorded details for chronic medical conditions such as obesity, diabetes, hypertension, CAD, chronic lung disease that includes COPD or sleep apnea, CKD stage III and above, including end stage renal disease. Baseline behavioral health conditions were also noted that included PTSD and depression. Along with high risk medical and behavioral conditions, immunocompromised patients like HIV, and patients on immunomodulators were also included.

Patients were categorized into mild, moderate, and severe disease based on their oxygen saturation and hemodynamic stability.

Following baseline data collection, patients were followed at 30, 60, 90 and 180 days to review their COVID related persistent symptoms, COVID or non-COVID related hospitalization rates, exacerbation of chronic conditions requiring optimal management.

Statistical Analysis

Analysis were performed by IBM SPSS Statistics software version 26. We recoded symptoms into numerical variable and combined symptoms by organ type for each set of post COVID days. Created deceased/exclude variable. Ran descriptives and frequencies on study variables. Created cross tabs for gender, ethnicity, pre-existing symptoms, and COVID severity. We did not calculate cross tabs for age because of the nature of age as a continuous variable, and included ethnicity instead. Created bar charts for frequencies of each symptom set at each time point. Created line graph of symptom set trajectories across timepoints.

The primary end points were persistence of residual symptoms and observance of new behavioral symptoms pertaining to COVID-19 illness. The secondary endpoint uncovered the discrepancy of COVID 19 illness based on demographics.

RESULTS

In the period of March-May 2020, 400 patients diagnosed with COVID-19 in Brooklyn VA Harbor hospital. All 400 patients were included in the analysis, but 89 (22.25%) of those patients died during first 30 days due to COVID 19 i

llness. 311 (77.75%) patients were discharged either to nursing care facilities or home. Two of those patients died between 60-90 days of follow up due to non-COVID related issues (advanced prostate cancer and cardiovascular problems) and the remaining 309 patients (77.3%) survived past 180 days. Three patients with moderate to severe COVID required supplemental oxygen via nasal cannula on discharge and another three patients with severe COVID was discharged to nursing facility with tracheal collar.

All patients were called via telehealth system at an average of 30, 60, 90 and 180 days, unless deceased. Majority of the patients were male (93.7%). More than half of the patients were African American (AA) (n = 201, 50.2%), remaining were White (W) (n =114, 28.5%), Hispanic (H) (n =71, 17.8%), Asian (A) (n= 2, 0.5%) and (n= 12, 3%) participants did not identify race and listed in our study as Unknown (Un). The average age of the participants was 67.8 years (SD = 14.16).

Patients were also categorized based on chronic medical conditions. The most common comorbidity was Hypertension (HTN) (n= 265, 66.2%), followed by Obesity (n =195, 48.8%), Diabetes Mellitus (DM) (n= 168, 42%), PTSD/Depression (n= 140, 35%), COPD/OSA (n= 107, 26.8%), CAD (n= 93, 23.3%), CKDIII-V/ESRD (n= 19, 15.8%). Out of the total analysis, 19 (4.7%) were on immunomodulators (IM), 16 (4.0%) were immunocompromised secondary to HIV/AIDS. Majority of the symptomatic patients presented with mild disease (n= 213, 53.2%) with moderate and severe symptoms comprising of n= 75, 18.8% and n= 112, 28%, respectively.

Table 1. The demographics and clinical characteristics

Variable			N	%
Ethnicity				
		African American	201	50.2
		Asian	2	0.5
		Hispanic	71	17.8
		Unknown	12	3.0
		White	114	28.5
Sex				
		Female	25	6.3
		Male	375	93.7
Obesity				
		No	205	51.2
		Yes	195	48.8
DM				
		No	232	58.0
		Yes	168	42.0
HTN				
		No	135	33.8
		Yes	265	66.2
CAD				
		No	307	76.7
		Yes	93	23.3
COPD/OSA				
		No	293	73.2
		Yes	107	26.8
PTSD/Dep				
		No	260	65.0
		Yes	140	35.0
CKD/ESRD				
		No	337	84.2
		Yes	19	15.8
Immunomodulators				
		No	381	95.3
		Yes	19	4.7
HIV				
		No	384	96.0
		Yes	16	4.0
COVID				
		Mild	213	53.2
		Moderate	75	18.8
		Severe	112	28.0
Total			400	100

At Day 30, persistent respiratory symptoms such as cough, shortness of breath and dyspnea on exertion were reported by 124 (31%) patients and was observed as most common symptom in this time frame. During the same time frame, 23 (5.8%) patients had behavioral outcomes such as anxiety, agoraphobia, thanatophobia, worsening depression and PTSD. Seven (1.8%) patients from same cohort had cardiac outcomes like atrial fibrillation, myocardial infarction. Three (0.8%) patients had musculoskeletal outcomes such as back pain and myalgia. One (0.3%) patient reported gastrointestinal (GI) symptoms such as diarrhea, it was Hispanic male with PTSD. No patients were reported with renal dysfunction within 30 days.

At Day 60, majority of patients had behavioral health outcomes (n= 29, 9.3%), followed by

respiratory (n= 19, 6.1%), cardiac (n=4, 1.3%), musculoskeletal (n=3, 1.0%), GI (n= 1, 0/3%). No renal symptoms were observed within 60 days.

At Day 90, we still observed that majority of the outcomes were related to behavioral health (n =22, 7.1%). It was followed by respiratory (n = 15, 4.9%), musculoskeletal (n=5, 1.6%), cardiac (n=4, 1.3%), GI (n=1, 0.3%), Renal (0, 0%) symptoms.

At day 180, the most prevalent outcome was still behavioral health (n=27, 8.7%), followed by respiratory (n=12, 3.9%), musculoskeletal (n=5, 1/6%), cardiac (n= 3, 1.0%), Renal (n=2, 0.6%), GI (n= 1, 0.3%). Renal symptoms included acute renal failure.

Table 2: Frequencies for Post-COVID Symptoms by Organ Functioning Group

Days Post COVID	30 Day		60 Day		90 Day		180 Day	
Symptom Set	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*
CNS	0	0.0	0	0.0	0	0.0	0	0.0
Behavioral	23	5.8	29	9.3	22	7.1	27	8.7
Cardiac	7	1.8	4	1.3	4	1.3	3	1.0
Respiratory	124	31.0	19	6.1	15	4.9	12	3.9
GI	1	0.3	1	0.3	1	0.3	1	0.3
Musculoskeletal	3	0.8	3	1.0	5	1.6	5	1.6
Renal	0	0.0	0	0.0	0	0.0	2	0.6

*Note: Percentage for 30 Days is calculated out of *N* = 400 for each set of organ functioning symptom; 60 Days is calculated out of *N* = 311; 90 and 180 Days are calculated out of *N* = 309

We classified our analysis at 30, 60, 90 and 180 days based on gender. On day 30, majority of patients with persistent respiratory symptoms were observed in male population. Out of total 124 patients with respiratory symptoms, 118 were males and 6 were females. Behavioral health outcomes were seen in 21 males and 2 females, MSK outcome was observed in 2 males and 1 female. Rest of all patients with cardiac and GI symptoms were males (n= 7, 1, respectively)

At 60 days: Behavioral outcomes were observed in 27 males and 2 females, respiratory symptoms were seen in 18 males and 1 female. Rest of all outcomes, such as GI, cardiac and MSK, were observed in male populations only.

At 90 days: 20 males and 2 females were noted to have behavioral outcomes, 14 males and 1 female had persistent respiratory symptoms. Rest of outcomes were observed only in males.

At 180 days: 24 males and 3 females had persistent behavioral outcomes. Rest of outcomes were observed only in males.

Table 3: Cross Tabs for Post-COVID Symptoms by Gender

Symptom Set	F	M	Total
30 Days Post			
CNS	0	0	0
Behavioral	2	21	23
Cardiac	0	7	7
Respiratory	6	118	124
GI	0	1	1
Musculoskeletal	1	2	3
Renal	0	0	0
60 Days Post			
CNS	0	0	0
Behavioral	2	27	29
Cardiac	0	4	4
Respiratory	1	18	19
GI	0	1	1
Musculoskeletal	0	3	3
Renal	0	0	0
90 Days Post			
CNS	0	0	0
Behavioral	2	20	22

Cardiac	0	4		4
Respiratory	1	14		15
GI	0	1		1
Musculoskeletal	0	5		5
Renal	0	0		0
180 Days Post				
CNS	0	0		0
Behavioral	3	24		27
Cardiac	0	3		3
Respiratory	0	12		12
GI	0	1		1
Musculoskeletal	0	5		5
Renal	0	2		2

We also classified the patients based on ethnicity categorized as African American, Asian, White, Hispanic and Unknown. African Americans have most of the individual and total number of respiratory and behavioral outcomes at day 30. 59 of African Americans patients have respiratory symptoms, followed by Whites (n=39), Hispanics (n= 20). 12 of African American patients had behavioral outcomes, whereas 3 of the Hispanics and 1 Unknown had similar outcome at day 30.

At Day 60, 15 African Americans, 10 Whites and 4 Hispanics out of 29 had behavioral outcomes. 10 AA, 6 Hispanics and 3 whites out of 20 had respiratory symptoms. Hispanics exceeded African Americans only in cardiac outcomes, n=2 and 1 respectively.

At Day 90, 14 African Americans, 6 Whites and 2 Hispanics out of 22 had behavioral outcomes. Among respiratory symptoms, 6 were AA, 5 were whites and 4 were Hispanics. Whites had more musculoskeletal symptoms than AA (n= 3 and 1, respectively).

At day 180, 14 African American, 4 Hispanics and 1 White out of 28 had behavioral outcomes. Among respiratory symptoms, 7 were African Americans, 3 were Whites and 2 were Hispanics.

Table 4: Cross Tabs for Post-COVID Symptoms by Ethnicity

Symptom Set	AA	A	H	W	Unknown	Total
30 Days Post						
CNS	0	0	0	0	0	0
Behavioral	12	0	3	0	1	24
Cardiac	2	0	3	2	0	7
Respiratory	59	0	20	39	6	124
GI	0	0	1	0	0	1
Musculoskeletal	2	0	0	1	0	3
Renal	0	0	0	0	0	0
60 Days Post						
CNS	0	0	0	0	0	0
Behavioral	15	0	4	10	0	29
Cardiac	1	0	2	1	0	4
Respiratory	10	0	6	3	1	20
GI	0	0	1	0	1	2
Musculoskeletal	1	0	0	2	0	3
Renal	0	0	0	0	0	0
90 Days Post						
CNS	0	0	0	0	0	0
Behavioral	14	0	2	6	0	22
Cardiac	1	0	2	1	0	4
Respiratory	6	0	4	5	0	15
GI	0	1	0	0	0	1
Musculoskeletal	1	0	1	3	1	6
Renal	0	0	0	0	0	0
180 Days Post						
CNS	0	0	0	0	0	0
Behavioral	14	0	4	1	1	28

Cardiac	1	0	1	1	0	3
Respiratory	7	0	2	3	0	12
GI	0	0	1	0	0	1
Musculoskeletal	2	0	1	2	1	6
Renal	0	0	1	1	0	2

Based on classification of severity of symptoms, majority of the respiratory symptoms were observed in severe COVID 19 illness at day 30. 96 out of 124 patients had severe illness. Behavioral outcomes were noted mainly in mild COVID 19 illness (n= 20, 0.87%).

At day 60, behavioral symptoms were observed in 24 out of 29 patients with mild COVID 19 illness. Resp symptoms were mainly observed with mild and moderate COVID 19, (n= 8, 0.42%) in each category.

At day 90, behavioral and respiratory symptoms were observed more in mild COVID 19 illness again. 16 out of 22 patients (72.7%) were observed with behavioral, 8 out of 15 (53.3%) were observed were respiratory outcomes.

At day 180, we observed similar outcomes among behavioral (n= 19, 70.4%) and respiratory (n=5, 41.7%) symptoms as majority were seen in mild COVID 19 illness.

Table 5: Cross Tabs for Post-COVID Symptoms by COVID Severity

Symptom Set	Mild	Moderate	Severe	Total
30 Days Post				
CNS	0	0	0	0
Behavioral	20	2	1	23
Cardiac	6	0	1	7
Respiratory	14	14	96	124
GI	1	0	0	1
Musculoskeletal	3	0	0	3
Renal	0	0	0	0
60 Days Post				
CNS	0	0	0	0
Behavioral	24	4	1	29
Cardiac	4	0	0	4
Respiratory	8	8	3	19
GI	1	0	0	1
Musculoskeletal	2	0	1	3
Renal	0	0	0	0
90 Days Post				
CNS	0	0	0	0
Behavioral	16	4	2	22
Cardiac	4	0	0	4
Respiratory	8	3	4	15
GI	1	0	0	1
Musculoskeletal	4	0	1	5
Renal	0	0	0	0
180 Days Post				
CNS	0	0	0	0
Behavioral	19	5	3	27
Cardiac	3	0	0	3
Respiratory	5	4	3	12
GI	1	0	0	1

Musculoskeletal	4	0	1	5
Renal	0	1	1	2

At day 30, respiratory symptoms were mainly observed with chronic comorbidities such as HTN (n= 79), obesity (n= 56), and diabetes (n= 47). For patients with behavioral outcomes, the most observed comorbidities were CKD (n= 23), PTSD (n=18), obesity (n= 17) and HTN (n=16).

At day 60, behavioral outcomes were most commonly observed among PTSD/depression (n= 22), hypertensive (n=21), and obese (n= 20) patients. Respiratory symptoms were mostly seen in HTN (n=11), obesity (n=11) and DM (n=9).

At day 90, behavioral outcomes were observed mainly in PTSD/Depression (n=15), HTN (n=13), Obesity (n=13). Respiratory: Obesity (n=13), HTN (n=9), COPD and Diabetes (n= 7).

At day 180, behavioral outcomes were similar to patients at 60 and 90 da follow up: PTSD/depression (n=18), obesity (n=16) and HTN (n=13), respectively. Respiratory symptoms were observed in obesity (n=7), HTN (n=6) and diabetes (n=6), which were similar association at 60 and 90 days.

None of the patients had new onset CNS symptoms during the 30, 60, 90 and 180 day follow up.

Table 6: Cross Tabs for Post-COVID Symptoms by Comorbidities

	Obese	DM	HTN	CAD	COPD	P/D	CKD	HIV	Imm
Symptom Set	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
30 Days Post									
CNS	0	0	0	0	0	0	0	0	0
Behavioral	17	9	16	4	5	18	23	2	1
Cardiac	4	3	4	1	1	4	0	1	0
Respiratory	56	47	79	40	32	34	23	3	6
GI	0	0	0	0	0	1	0	0	0
Musculo	2	0	2	1	1	0	1	1	0
Renal	0	0	0	0	0	0	0	0	0
60 Days Post									
CNS	0	0	0	0	0	0	0	0	0
Behavioral	20	11	21	6	6	22	3	3	0
Cardiac	0	1	2	1	0	3	0	1	0
Respiratory	11	9	11	3	7	6	5	0	0
GI	0	0	1	0	0	1	0	0	0
Musculo	3	1	2	1	1	1	0	0	0
Renal	0	0	0	0	0	0	0	0	0
90 Days Post									
CNS	0	0	0	0	0	0	0	0	0
Behavioral	13	8	13	4	4	15	1	4	1
Cardiac	0	1	2	1	0	3	0	1	0
Respiratory	13	7	9	2	7	3	4	0	1
GI	0	0	1	0	0	1	0	0	0
Musculo	3	2	4	3	1	3	0	1	0
Renal	0	0	0	0	0	0	0	0	0
180 Days Post									
CNS	0	0	0	0	0	0	0	0	0
Behavioral	16	9	13	4	6	18	2	5	1
Cardiac	1	0	2	1	1	3	0	2	0
Respiratory	7	6	6	4	5	2	4	1	1
GI	0	0	1	0	0	1	0	0	0

| Musculo | 4 | 3 | 4 | 1 | 3 | 1 | 0 | 0 | 0 |
| Renal | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |

DISCUSSION

Our study investigated long-term pulmonary and extrapulmonary organ manifestations, hospitalizations, and death during 30, 60, 90 and 180 days follow up.

We found out that at 30 days follow up, majority of the patients were suffering from respiratory symptoms followed by behavioral outcomes. However, at 60, 90 and 180 days, majority of the patients had behavioral outcomes followed by respiratory symptoms. The persistence or worsening of depression and anxiety 180 days later was also observed in other studies. Huang et al followed patients at 6 months and found that depression, anxiety, fatigue or muscle weakness were still present in the patients affected with COVID 19 illness [Huang, C. *et al*., 2021]. Chopra et all observed 488 patients for 60 days who were discharged from 38 Michigan Hospitals between March 16 and July 1, 2020 and almost 49 % of patients presented with behavioral abnormalities and 33% with residual respiratory symptoms [Chopra, V. *et al*., 2021].

It was also noted that obesity, diabetes, hypertension, and PTSD/depression were the most common comorbidities linked to the most common outcomes. In one of the outcomes, CKD was observed to be the most common associated comorbidity linked to behavioral outcomes post day 30 follow up. However, majority of the behavioral outcomes were linked to hypertension, obesity and PTSD/depression. It is not surprising to note that PTSD/depression was the main associating factor observed in behavioral outcomes at 30, 60, 90 and 180 day follow up. It is also interesting to note that respiratory outcomes were mainly observed with hypertension, obesity and diabetes comorbidities. COPD was only observed as one of the main underlying risk factors for respiratory outcomes at 90 day follow up. CNS outcomes were not observed at any of the follow up intervals possibly because they are more likely the cause of presenting symptom of COVID 19 illness rather than a later development. However, it is difficult to make such interpretation and further studies are needed to assess that data.

This study also had few limitations. Firstly, patients were mostly male veterans from Brooklyn VA harbor hospital and the results maybe not be generalized to other patient populations. Secondly, our long-term results relied on self-reporting of patient symptoms in the most cases, which could cause underestimation of outcomes. Thirdly, few patients deceased from COVID complications after 30 days, which could have contributed to the decreased number of respiratory symptoms in the 60 day follow up. Finally, our patients had a large pool of underlying behavioral comorbidities due to the nature of their occupation. This could have led to overestimation of behavioral outcomes compared to general population.

This study has taught us the importance of follow up in patients with COVID 19 illness with mild, moderate, and severe disease. It is unclear if mild disease requires less frequent follow up than moderate and severe disease. It is also unclear if some underlying behavioral problems like anxiety contributed to short term shortness of breath or dyspnea on exertion in the initial 30 day follow up. Further studies are needed to develop necessary follow up intervals with mild, moderate and severe disease to improve outcomes in patients. Also, there might be a need to develop specific COVID clinics where multi-disciplinary help can be provided to decrease the persistence of respiratory and behavioral symptoms. This might include respiratory and behavioral therapists to cope with overlapping symptoms. This study also pointed out the significant number of behavioral complications with or without underlying behavioral problems. COVID- 19 illness is usually known to cause acute or prolonged respiratory symptoms, but we observed many cases with worsening or persistent behavioral problems.

Author Contributions

KB, AK, JP performed the study concept and design. KB and AK participated in data acquisition. KB and AK performed overall data analysis and interpretation of data. Stats team performed the statistical analysis. KB and AK wrote the draft of the manuscript. All authors had full access to the data and contributed to the critical revision and final approval of the manuscript.

Ethics Approval

This study was approved by the Institutional Review Board at Brooklyn VA Harbor hospital.

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Cite this article as:

Balabayova, K., Kaar, A. and Viderman, D. "Short Term and Long Term Implications of Covid-19 among Veterans at the New York VA HealthCare System Hospital, USA." *Sarcouncil Journal of Medical Series* 1.2 (2022): pp 1-11