Received: 26 June 2020 | Accepted: 17 July 2020

DOI: 10.1002/jmv.26337

RESEARCH ARTICLE

JOURNAL OF MEDICAL VIROLOGY WILEY

Risk factors and outcomes of COVID-19 in New York City; a retrospective cohort study

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Abstract

Coronavirus disease 2019 (COVID-19) is a global pandemic and information on risk factors for worse prognosis is needed to accurately identify patients at risk and potentially provide insight into therapeutic options. In this retrospective cohort study, including 3703 patients with laboratory confirmed COVID-19, we identified risk factors associated with all-cause mortality, need for hospitalization and mechanical ventilation. Male gender was independently associated with increased risk of hospitalization (adjusted odds ratio [OR_{adj}]: 1.62; 95% confidence interval [95% CI]: 1.38-1.91)), mechanical ventilation (OR_{adj}: 1.35; 95% CI: 1.08-1.69) and death (OR_{adj}: 1.46; 95% CI: 1.17-1.82). Patients > 60 years had higher risk of hospitalization (OR_{adj}: 5.47; 95% CI: 4.29-6.96), mechanical ventilation (OR_{adj}: 3.26; 95% CI: 2.08-5.11) and death (OR_{adj}: 13.04; 95% CI: 6.25-27.24). Congestive heart failure (ORadj: 1.47; 95% CI: 1.06-2.02) and dementia (OR_{adj}: 2.03; 95% CI: 1.46-2.83) were associated with increased odds of death, as well as the presence of more than two comorbidities (OR_{adj}: 1.90; 95% CI: 1.35-2.68). Patients with COVID-19 of older age, male gender, or having more than two comorbidities are at higher risk of hospitalization, mechanical ventilation and death, and should therefore be closely monitored.

KEYWORDS

comorbidities, COVID-19, mechanical ventilation, New York City, survival

1 | INTRODUCTION

Amidst the current pandemic of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), New York City has emerged as the epicenter of the coronavirus disease 2019 (COVID-19) outbreak in the United States (US).[1-3] Initially most cases were identified outside the US, including China[4] and Italy[5]; the first confirmed COVID-19 case diagnosed in New York City was identified at the beginning of March 2020.[6] As of the end of April 2020, over 300 000 COVID-19 cases and over 18 000 COVID-19 related deaths were confirmed in New York State, with most cases diagnosed in New York City.[7]

Patients with SARS-CoV-2 develop COVID-19, a disease with a wide clinical spectrum ranging from an asymptomatic infection to severe viral pneumonia with respiratory failure and death.[8,9] COVID-19 has been associated with high rates of hospitalization, intensive care unit admissions, and need of respiratory support.[5,10] The Chinese Center for Disease Control and Prevention (CDC) reported that 14% of the patients with COVID-19 have severe disease and 5% have critical disease with a fatality rate of 49% among the critical cases.[4] Acute respiratory distress syndrome is common in severely ill patients with COVID-19 and often requires mechanical ventilation.[10] Recent data from New York City reported that of 5700 patients hospitalized with COVID-19, 14.2% required admission to the intensive care unit (ICU), 12.2% invasive mechanical ventilation, 3.2% renal replacement therapy and 21% ultimately died.[11]

To date, several risk factors associated with developing more severe COVID-19 have been identified in different populations and include male gender, older age, obesity and underlying health conditions, such as respiratory and cardiovascular disease, hypertension, diabetes, and cancer.[4,5,8,12-15] A systematic review including 18 studies reported that 36.8% of the COVID-19 cases presented with comorbidities, the most common being hypertension (18.6%), cardiovascular disease (14.4%) and diabetes (11.9%).[16] However, there still remains limited information regarding the presenting characteristics and outcomes of patients diagnosed with COVID in the US, especially as post-diagnosis follow-up time was too short for most studies to accurately identify mortality.

The majority of existing research on COVID-19 has come out of countries hit early by the virus, such as China and Italy. Importantly, population demographics, incidence rates and clinical outcomes for patients with COVID-19 have been noted to vary significantly throughout different regions of the world.[17]

The present study assesses the risk factors associated with the need for hospitalization and mechanical ventilation as well as all-cause mortality of all laboratory confirmed patients with COVID-19, diagnosed across a larger New York City health system in the month of March 2020 and outcomes as of 13th May 2020 with a minimum follow-up time of 6 weeks.

2 | METHODS

2.1 | Study population

All patients with a laboratory-confirmed diagnosis of COVID-19 between 1 March and 1 April 2020 were identified via the electronic medical record system across a large New York City health system (n = 4343). Confirmed COVID-19 was defined as a positive result on a reverse transcriptase-polymerase chain reaction SARS-CoV-2 assay of a nasopharyngeal swab specimen. Patients were ineligible and excluded if they were less than 18 years old (n = 55) or had insufficient clinical documentation available or accessible, including confidential patient records (n = 584). One additional patient was excluded because of unknown date of birth, resulting in a final study population of 3703 COVID-19 positive patients.

This study was approved by the Program for the Protection of Human Subjects of the Icahn School of Medicine at Mount Sinai. The funding source had no involvement in the design of the study, data collection, analysis, and interpretation of data.

2.2 | Data collection

The medical records of both hospitalized and ambulatory patients were retrospectively reviewed and relevant data was extracted and collected by the study investigators through a research form in Research Electronic Data Capture software (REDCap, Vanderbilt University). Data was collected on the following patient's characteristics: age, sex, race, smoking status, and body mass index (BMI) with the cut-offs used for normal weight (<25 kg/m^2), overweight (25-30 kg/m^2) and obese (>30 kg/m^2), as proposed by the CDC.[18] Data on the following comorbidities was collected: hypertension, coronary artery disease (CAD), atrial fibrillation, congestive heart failure (CHF), peripheral vascular disease (PVD), cerebrovascular accident/transient ischemic attack (CVA/TIA), dementia, diabetes, hypothyroidism, chronic kidney disease stage III or greater (CKD), malignancy (including all kinds of cancer as well as lymphoma and leukemia), asthma, chronic obstructive pulmonary disease (COPD) and prior venous thromboembolism (VTE). Data on the following primary outcomes of interest was collected up to 13th May 2020 and included hospital admission, need for invasive mechanical ventilation (ie, intubation), and all-cause mortality.

2.3 | Statistical analysis

Descriptive statistics were used to describe the study population. Age was presented as a continuous variable (mean and standard deviation) and a categorical variable as the following age groups: between 18 and 40 years, between 40 and 60 years, and older than 60 years. Categorical variables were presented as number of patients and percentages. Demographic and clinical characteristics were compared between the hospitalized and nonhospitalized groups using two-sized t test for the continuous variable age and χ^2 test, or Fisher's exact test for small sample size (n < 5), for the categorical variables. Within the hospitalized group, demographic, and clinical characteristics were compared between the group that received mechanical ventilation and the group that did not receive mechanical ventilation, between the survivor and non-survivor groups, and between the survivor and non-survivor group within the group of patients who received mechanical ventilation.

Adjusted analyses were performed using multivariable logistic regression for the outcomes of interest, adjusting for age group, gender, race, BMI, smoking status, and the previously described comorbidities. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, NC).

3 | RESULTS

The mean age of the study population of 3703 COVID positive patients was 56.8 years (Table 1). A little over half of the patients were male (55.3%); 27.4% were non-Hispanic White, 26.8% were non-Hispanic Black and 40.2% were of other race. Most patients were never- smokers (57.9%) and had a BMI below 25 (22.8%) or between 25 and 30 (28.5%). The most frequently found comorbidities were hypertension (44.4%), diabetes (28.2%), CAD (12.0%), and asthma (11.6%). Most patients had no (35.2%) or one (22.7%) of the included comorbidities reported (Table 1).

Of the 3703 patients, 2015 patients (54.4%) were hospitalized. Hospitalized patients were older (P < .001), more frequently male (P < .001), more likely to be former smokers (P < .001), and more

TABLE 1 Characteristics of the study population

		All patients (n = 3703)			Hospitalized (n = 2015)			Hospitalized (n = 2015)		
	All (n = 3703) (%)	Nonhospitalized (n = 1688) (%)	Hospitalized (n = 2015) (%)	*P* value	No mechanical ventilation (n = 1490) (%)	Mechanical ventilation (n = 525) (%)	*P* value	Survivor (n = 1399) (%)	Non-survivor (n = 616) (%)	*P* value
Age(y ± SD)	(56.8 ± 18.2)	(47.7 ± 16.0)	(64.5 ± 16.4)	<.001	(64.2 ± 17.3)	(65.4 ± 13.4)	.105	(61.0 ± 16.4)	(73.5 ± 13.2)	<.001
Age groups, y, n (%)				<.001			<.001			<.001
18-40	861 (23.2)	654 (38.7)	207 (10.3)		178 (12.0)	29 (5.5)		199 (14.2)	8 (1.3)	
40-60	1173 (31.7)	634 (37.6)	539 (26.7)		404 (27.1)	135 (25.7)		438 (31.3)	101 (16.4)	
>60	1669 (45.1)	400 (23.7)	1269 (63.0)		908 (60.9)	361 (68.8)		762 (54.5)	507 (82.3)	
Male, n (%)	2049 (55.3)	868 (51.4)	1181 (58.6)	<.001	855 (57.4)	326 (62.1)	.059	799 (57.1)	382 (62.0)	.034
Race, n (%)				<.001			.089			.167
NHW	1013 (27.4)	490 (29.0)	523 (26.0)		408 (27.4)	115 (21.9)		345 (24.7)	178 (28.9)	
NHB	992 (26.8)	459 (27.2)	533 (26.4)		391 (26.2)	142 (27.1)		370 (26.5)	163 (26.5)	
Other	1489 (40.2)	621 (37.8)	868 (43.1)		627 (42.1)	241 (45.9)		622 (44.5)	246 (39.9)	
Unknown	209 (5.6)	118 (7.0)	91 (4.5)		64 (4.3)	27 (5.1)		62 (4.4)	29 (4.7)	
Smoking, n (%)				<.001			.468			<.001
Never	2144 (57.9)	980 (58.1)	1164 (57.8)		864 (58.0)	300 (57.1)		847 (60.5)	317 (51.5)	
Former	713 (19.3)	241 (14.3)	472 (23.4)		356 (23.9)	116 (22.1)		304 (21.7)	168 (27.3)	
Current	193 (5.2)	86 (5.1)	107 (5.3)		79 (5.3)	28 (5.3)		76 (5.4)	31 (5.0)	
Unknown	653 (17.6)	381 (22.6)	272 (13.5)		191 (12.8)	81 (15.4)		172 (12.3)	100 (16.2)	
BMI, n (%)				<.001			<.001			.015
<25	845 (22.8)	338 (20.0)	507 (25.2)		387 (26.0)	120 (22.9)		324 (23.2)	183 (29.7)	
25-30	1056 (28.5)	375 (22.2)	681 (33.8)		515 (34.6)	166 (31.6)		492 (35.2)	189 (30.7)	
>30	1072 (29.0)	366 (21.7)	706 (35.0)		486 (32.6)	220 (41.9)		500 (35.7)	206 (33.4)	
Unknown	730 (19.7)	609 (36.1)	121 (6.0)		102 (6.9)	19 (3.6)		83 (5.9)	38 (6.2)	
Comorbidities n (%)										
Hypertension	1643 (44.4)	462 (27.4)	1181 (58.6)	<.001	857 (57.5)	324 (61.7)	.093	757 (54.1)	424 (68.8)	<.001
CAD	446 (12.0)	73 (4.3)	373 (18.5)	<.001	279 (18.7)	94 (17.9)	.677	220 (15.7)	153 (24.8)	<.001
Atrial fibrillation	313 (8.5)	55 (3.3)	258 (12.8)	<.001	189 (12.7)	69 (13.1)	.787	147 (10.5)	111 (18.0)	<.001
CHF	292 (7.9)	42 (2.5)	250 (12.4)	<.001	178 (12.0)	72 (13.7)	.291	135 (9.7)	115 (18.7)	<.001
PVD	139 (3.8)	27 (1.6)	112 (5.6)	<.001	80 (5.4)	32 (6.1)	.532	66 (4.7)	46 (7.5)	.013
CVA/TIA	212 (5.7)	25 (1.5)	187 (9.3)	<.001	144 (9.7)	43 (8.2)	.317	109 (7.8)	78 (12.7)	<.001
Dementia	202 (5.5)	19 (1.1)	183 (9.1)	<.001	152 (10.2)	31 (5.9)	.003	84 (6.0)	99 (16.1)	<.001
Diabetes	1045 (28.2)	250 (14.8)	795 (39.5)	<.001	552 (37.1)	243 (46.3)	<.001	502 (35.9)	293 (47.6)	<.001
Hypothyroidism	251 (6.8)	80 (4.7)	171 (8.5)	<.001	124 (8.3)	47 (9.0)	.656	111 (7.9)	60 (9.7)	.180
CKD	346 (9.3)	53 (3.1)	293 (14.5)	<.001	218 (14.6)	75 (14.3)	.847	176 (12.6)	117 (19.0)	<.001

(Continues)

TABLE 1 (Continued)

	All patients (n = 3703)				Hospitalized (n = 2015)			Hospitalized (n = 2015)		
	All (n = 3703) (%)	Nonhospitalized (n = 1688) (%)	Hospitalized (n = 2015) (%)	*P* value	No mechanical ventilation (n = 1490) (%)	Mechanical ventilation (n = 525) (%)	*P* value	Survivor (n = 1399) (%)	Non-survivor (n = 616) (%)	*P* value
Malignancy	312 (8.4)	84 (5.0)	228 (11.3)	<.001	176 (11.8)	52 (9.9)	.236	147 (10.5)	81 (13.2)	.085
Asthma	430 (11.6)	198 (11.7)	232 (11.5)	.838	167 (11.2)	65 (12.4)	.469	171 (73.7)	61 (26.3)	.133
COPD	172 (4.6)	27 (1.6)	145 (7.2)	<.001	104 (7.0)	41 (7.8)	.527	85 (6.1)	60 (9.7)	.003
Prior VTE	129 (3.5)	40 (2.4)	89 (4.4)	<.001	69 (4.6)	20 (3.8)	.431	63 (4.5)	26 (4.2)	.776
Number of comorbiditiesn (%)				<.001			.433			<.001
0	1305 (35.2)	903 (53.5)	402 (20.0)		307 (20.6)	95 (18.1)		334 (23.9)	68 (11.0)	
1	841 (22.7)	411 (24.3)	430 (21.3)		322 (21.6)	108 (20.6)		326 (23.3)	104 (16.9)	
2	627 (16.9)	212 (12.6)	415 (20.6)		297 (19.9)	118 (22.5)		287 (20.5)	128 (20.8)	
>2	930 (25.1)	162 (9.6)	768 (38.1)		564 (37.9)	204 (38.9)		452 (32.3)	316 (51.3)	

Abbreviations: BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; NHB, non-Hispanic Black; NHW, non-Hispanic White; prior VTE, prior venous thromboembolism; PVD, peripheral vascular disease.

likely to have a BMI > 25 ($P < .001$). All comorbidities, except asthma, were more common among hospitalized compared with non-hospitalized patients ($P < .001$). Hospitalized patients were more likely to carry two or more comorbidities relative to nonhospitalized patients ($P < .001$) (Table 1).

Of the 2015 hospitalized patients, 525 patients (26.1%) received mechanical ventilation. There was no statistically significant difference in age between the group that received mechanical ventilation and the group that did not, although older patients received mechanical ventilation more often. Patients with a higher BMI received mechanical ventilation more frequently ($P < .001$). Patients with dementia received mechanical ventilation less frequently ($P < .003$), while patients with diabetes received mechanical ventilation significantly more frequently ($P < .001$). There was no difference with regard to mechanical ventilation for the other studied comorbidities, nor for the number of comorbidities (Table 1).

Of the 2015 hospitalized patients, 616 patients (30.6%) did not survive. Patients who did not survive were older ($P < .001$), more frequently male ($P < .034$), and more frequently former smokers ($P < .001$). All studied comorbidities, except hypothyroidism, malignancy, asthma, and prior VTE, were more reported among non-survivors compared with survivors ($P < .001$). Non-survivors were also significantly more likely to have more than two comorbidities ($P < .001$) (Table 1).

Of the 525 patients on mechanical ventilation, 379 patients (72.2%) did not survive. Non-survivors were older ($P < .001$), more frequently male ($P < .011$), and had the following comorbidities more frequently reported: hypertension, CAD, CHF, dementia, diabetes, CKD, as well as more than two comorbidities reported. (Table S1)

3.1 | Hospitalization

Adjusted analysis showed that patients between 40 and 60 years were more likely to be hospitalized compared with patients younger than 40 years (adjusted odds ratio [OR_{adj}]: 2.02; 95% confidence interval [CI]: 1.62-2.50); patients >60 years were also more likely to be hospitalized compared with patients between 18 and 40 years (OR_{adj}: 5.47; 95% CI: 4.29-6.96) (Table 2). Male patients were also more likely to be hospitalized compared with female patients (OR_{adj}: 1.62; 95% CI: 1.38-1.91) (Table 2). When stratified by age group, male patients were more likely to be hospitalized compared with female patients when older than 40 years (<40 years: OR_{adj}: 1.20; % % CI: 0.75-1.62); (40-60 years: OR_{adj}: 2.38; 95% CI: 1.79-3.15); (>60 years: OR_{adj} 1.47; 95% CI: 1.14-1.89). Patients with a BMI between 25 and 30 or a BMI > 30 were more likely to be hospitalized compared with patients with patients with a BMI < 25 with an OR_{adj}: 1.28; 95% CI: 1.03-1.59 and OR_{adj} 1.54; 95% CI: 1.23-1.92, respectively. Former smokers were less likely to be hospitalized compared with never smokers (OR_{adj}: 0.72; 95% CI: 0.58-0.90). The following comorbidities were associated with an increased risk of hospitalization: atrial fibrillation (OR_{adj}: 1.49; 95% CI: 1.03-2.14), CVA/TIA (OR_{adj}: 2.25; 95% CI: 1.42-3.58), dementia (OR_{adj}: 3.60; 95% CI: 2.12-

TABLE 2 Unadjusted and adjusted association between patient's characteristics and COVID-19 outcomes

			Hospitalized patients					
	Hospitalization		Mechanical ventilation		Death		Mechanical ventilation and death	
	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)
Age group, y								
18-40	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
40-60	2.69 (2.21-3.26)	2.02 (1.62-2.50)	2.05 (1.32-3.18)	2.12 (1.35-3.32)	5.74 (2.74-12.01)	5.29 (2.51-11.15)	3.82 (1.58-9.24)	3.79 (1.49-9.60)
>60	10.02 (8.27-12.15)	5.47 (4.29-6.96)	2.44 (1.62, 3.68)	3.26 (2.08-5.11)	16.55 (8.09-33.85)	13.04 (6.25-27.24)	10.91 (4.64-25.66)	8.67 (3.44-21.87)
Gender								
Female	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Male	1.34 (1.17-1,52)	1.62 (1.38-1.91)	1.22 (0.99-1.49)	1.35 (1.08-1.69)	1.23 (1.01-1.49)	1.46 (1.17-1.82)	1.65 (1.12-2.43)	2.04 (1.28-3.26)
Race								
NHW	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
NHB	1.09 (0.91-1.30)	1.08 (0.86-1.35)	1.29 (0.97-1.71)	1.31 (0.97-1.77)	0.85 (0.66-1.11)	0.96 (0.72-1.28)	0.97 (0.54-1.73)	0.78 (0.39-1.54)
Other	1.31 (1.12-1.54)	1.51 (1.24-1.85)	1.36 (1.06-1.76)	1.52 (1.16-1.98)	0.77 (0.61-0.97)	0.98 (0.76-1.27)	0.62 (0.37-1.04)	0.63 (0.35-1.16)
Unknown	0.72 (0.54-0.98)	0.89 (0.61-1.29)	1.50 (0.91-2.46)	1.53 (0.92-2.55)	0.91 (0.56-1.46)	1.00 (0.56-1.66)	0.50 (0.20-1.22)	0.58 (0.21-1.56)
Smoking								
Never	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Former	1.65 (1.38-1.97)	0.72 (0.58-0.90)	0.94 (0.73-1.20)	0.83 (0.63-1.08)	1.48 (1.18-1.86)	1.05 (0.82-1.35)	1.82 (1.08-3.05)	1.25 (0.69-2.28)
Current	1.05 (0.78-1.41)	0.87 (0.61-1.25)	1.02 (0.65, 1.60)	0.83 (0.63-1.08)	1.09 (0.70-1.69)	1.06 (0.66-1.72)	0.81 (0.36-1.82)	0.67 (0.27-1.62)
Unknown	0.60 (0.50-0.72)	1.77 (1.37-2.29)	1.22 (0.91-1.63)	1.43 (1.05-1.95)	1.55 (1.18-2.05)	1.65 (1.21-2.25)	1.37 (0.78-2.40)	1.39 (0.74-2.63)
BMI								
<25	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
25-30	1.21 (1.01-1.46)	1.28 (1.03-1.59)	1.04 (0.79-1.36)	0.99 (0.75-1.30)	0.68 (0.53-0.87)	0.82 (0.63-1.07)	1.04 (0.62-1.75)	1.16 (0.64-2.09)
>30	1.29 (1.07-1.55)	1.54 (1.23-1.92)	1.46 (1.13-1.89)	1.52 (1.15-2.0)	0.73 (0.57-0.93)	1.06 (0.81-1.38)	1.07 (0.66-1.76)	1.54 (0.88-2.70)
Unknown	0.13 (0.10-0.17)	0.16 (0.12-0.22)	0.60 (0.35-1.02)	0.50 (0.29-0.87)	0.81 (0.53-1.24)	1.01 (0.63-1.61)	2.20 (0.60-8.01)	1.90 (0.48-7.55)
Hypertension	3.76 (3.27-4.32)	1.15 (0.95-1.39)	1.19 (0.97-1.46)	0.93 (0.73-1.19)	1.87 (1.53-2.29)	1.08 (0.85-1.37)	2.48 (1.68-3.67)	1.64 (1.00-2.68)
CAD	5.03 (3.87-6.52)	1.31 (0.96-1.80)	0.95 (0.73-1.23)	0.80 (0.59-1.08)	1.77 (1.40-2.24)	0.97 (0.74-1.28)	2.52 (1.38-4.61)	1.85 (0.90-3.79)
Atrial fibrillation	4.36 (3.23-5.88)	1.49 (1.03-2.14)	1.04 (0.78-1.40)	1.06 (0.75-1.48)		1.19 (0.87-1.62)	1.11 (0.62-1.97)	0.54 (0.26-1.11)
CHF	5.55 (3.97-7.75)	1.25 (0.84-1.86)	1.17 (0.87-1.57)	1.22 (0.86-1.72)	2.15 (1.64-2.81)	1.47 (1.06-2.02)	2.35 (1.20-4.61)	1.51 (0.65-3.52)
PVD	3.62 (2.37-5.54)	0.81 (0.50-1.30)	1.14 (0.75-1.75)	1.08 (0.69-1.70)	1.63 (1.11-2.41)	1.10 (0.72-1.68)	1.40 (0.59-3.32)	0.69 (0.26-1.86)
CVA/TIA	6.81 (4.46-10.38)	2.25 (1.42-3.58)	0.83 (0.58-1.19)	0.81 (0.56-1.18)	1.72 (1.26-2.33)	1.04 (0.74-1.45)	2.08 (0.91-4.80)	1.15 (0.45-2.89)
Dementia	8.77 (5.45-14.14)	3.60 (2.12-6.09)	0.55 (0.37-0.82)	0.52 (0.34-0.80)	3.00 (2.20-4.08)	2.03 (1.46-2.83)	5.97 (1.41-25.33)	6.36 (1.29-31.34)
Diabetes	3.75 (3.19-4.40)	1.71 (1.40-2.09)	1.46 (1.20-1.79)	1.35 (1.08-1.69)	1.62 (1.34-1.96)	1.25 (1.00-1.55)	1.63 (1.10-2.41)	1.17 (0.73-1.87)

(Continues)

TABLE 2 (Continued)

			Hospitalized patients					
	Hospitalization		Mechanical ventilation		Death		Mechanical ventilation and death	
	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)
Hypothyroidism	1.86 (1.42-2.45)	1.21 (0.87-1.69)	1.08 (0.76-1.54)	1.17 (0.81-1.70)	1,.25 (0.90-1.74)	1.09 (0.76-1.56)	0.81 (0.42-1.54)	0.64 (0.30-1.34)
CKD	5.25 (3.89-7.09)	1.88 (1.33-2.66)	0.97 (0.73-1.29)	0.83 (0.60-1.13)	1.63 (1.26-2.11)	1.16 (0.87-1.56)	2.00 (1.06-3.76)	1.19 (0.56-2.54)
Malignancy	2.44 (1.88-3.16)	1.19 (0.88-1.60)	0.82 (0.59-1.14)	0.82 (0.58-1.15)	1.29 (0.97-1.72)	1.03 (0.75-1.40)	1.95 (0.92-4.11)	1.38 (0.59-3.18)
Asthma	0.98 (0.80-1.20)	0.94 (0.74-1.20)	1.12 (0.83-1.52)	1.13 (0.82-1.55)	0.79 (0.58-1.08)	0.89 (0.64-1.25)	0.57 (0.33-0.98)	0.76 (0.41-1.40)
COPD	4.77 (3.15-7.23)	2.27 (1.41-3.65)	1.13 (0.78-1.64)	1.13 (0.75-1.70)	1.67 (1.18-2.36)	1.20 (0.82-1.75)	1.40 (0.65-3.02)	0.99 (0.41-2.40)
Prior VTE	1.90 (1.30-2.78)	0.87 (0.55-1.37)	0.82 (0.49-1.36)	0.76 (0.44-1.30)	0.94 (0.59-1.49)	0.75 (0.45-1.26)	1.16 (0.42-3.26)	1.23 (0.37-4.13)

Note: Adjusted for: age group, gender, race, BMI, smoking status, and comorbidities (hypertension, CAD, atrial fibrillation, CHF, PVD, CVA/TIA, dementia, diabetes, hypothyroidism, CKD, malignancy, asthma, COPD, prior VTE). Malignancy (includes all kinds of cancer as well as lymphoma and leukemia).

Abbreviations: BMI, body mass index; CAD, coronary artery disease; CHF, congestive heart failure; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; COVID-19, coronavirus disease 2019; NHB, non-Hispanic Black; NHW, non-Hispanic White; OR, odds ratio; prior VTE, prior venous thromboembolism; PVD, peripheral vascular disease.

TABLE 3 Unadjusted and adjusted association between the number of comorbidities and outcomes

			Hospitalized patients					
	Hospitalization		Mechanical ventilation		Death		Mechanical ventilation and death	
	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)	OR (95% CI)	OR_{adj} (95% CI)
Number of comorbidities[a]								
0	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
1	2.35 (1.97-2.81)	1.41 (1.14-1.73)	1.08 (0.79-1.49)	0.91 (0.65-1.26)	1.57 (1.11-2.21)	1.14 (0.79-1.65)	1.28 (0.73-2.27)	1.05 (0.56-1.97)
2	4.40 (3.59-5.39)	1.91 (1.50-2.42)	1.28 (0.94-1.76)	0.98 (0.69-1.37)	2.19 (1.57-3.06)	1.33 (0.92-1.91)	1.87 (1.05-3.33)	1.59 (0.83-3.04)
>2	10.65 (8.66-13.09)	3.45 (2.68-4.44)	1.17 (0.88-1.55)	0.85 (0.61-1.18)	3.43 (2.55-4.63)	1.90 (1.35-2.68)	3.14 (1.83-5.41)	2.12 (1.15-4.03)

Note: Adjusted for: age group, gender, race, BMI, smoking.

Abbreviations: BM, body mass index; CAD, coronary artery diseases; CHF, congestive heart failure; CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVA/TIA, cerebrovascular accident/transient ischemic attack; OR, odds ratio; PVD, peripheral vascular disease; prior VTE, prior venous thromboembolism.

[a]Comorbidities include: hypertension, CAD, atrial fibrillation, CHF, PVD, CVA/TIA, dementia, diabetes, hypothyroidism, CKD, malignancy (including all kinds of cancer as well as lymphoma and leukemia), asthma, COPD, prior VTE.

6.09), diabetes (OR_{adj}: 1.71; 95% CI: 1.40-2.09), CKD (OR_{adj}: 1.88; 95% CI: 1.33-2.66), and COPD (OR_{adj}: 2.27; 95% CI: 1.41-3.65) (Table 2). One (OR_{adj}: 1.41; 95% CI: 1.14-1.73), two (OR_{adj}: 1.91; 95% CI: 1.50-2.42), or more than two (OR_{adj}: 3.45; 95% CI: 2.68-4.44) comorbidities were associated with increased risk of hospitalization compared with no comorbidities (Table 3).

3.2 | Mechanical ventilation in hospitalized patients

After adjustment, patients between 40 and 60 years were more likely to receive mechanical ventilation compared with patients between 18 and 40 years (OR_{adj}: 2.12; 95% CI: 1.35-3.32) as well as patients >60 years (OR_{adj}: 3.26; 95% CI: 2.08-5.11) (Table 2). Male patients were also more likely to receive mechanical ventilation compared with female patients (OR_{adj}: 1.35; 95% CI: 1.08-1.69). Patients with a BMI > 30 were more likely to receive mechanical ventilation compared with patients with a BMI < 25 (OR_{adj}: 1.52; 95% CI: 1.15-2.00). Of the comorbidities, only diabetes was associated with an increased risk of mechanical ventilation (OR_{adj}: 1.35; 95%: 1.08-1.69). Dementia was associated with a decreased risk of mechanical ventilation (OR_{adj}: 0.52; 95%: 0.34-0.80) (Table 2). No difference in risk of mechanical ventilation was found between zero and one or more comorbidities (Table 3).

3.3 | Mortality in hospitalized patients

After adjustment, the odds of death were higher for patients between 40 and 60 years (OR_{adj}: 5.29 (95% CI: 2.51- 11.15)) as well as for patients >60 years (OR_{adj}: 13.04; 95% CI: 6.25-27.24), compared with patients 18 to 40 years (Table 2). Male patients had higher odds of death compared with female patients (OR_{adj}: 1.46; 95% CI: 1.17-1.82). CHF (OR_{adj}: 1.47; 95% CI: 1.06-2.02) and dementia (OR_{adj}: 2.03; 95% CI: 1.46-2.83) were associated with increased odds of death. (Table 2) The presence of more than two comorbidities was associated with increased odds of death compared with no comorbidities (OR_{adj}: 1.90; 95% CI: 1.35-2.68) (Table 3).

3.4 | Mortality in hospitalized patients on mechanical ventilation

After adjustment, the odds of death among patients on mechanical ventilation were higher for patients between 40 and 60 years (OR_{adj}: 3.79 (95% CI: 1.49- 9.60)) as well as for patients >60 years (OR_{adj}: 8.67; 95% CI: 3.44-21.87), compared with patients 18 to 40 years. (Table 2) Male patients had a higher odds of death compared with female patients (OR_{adj}: 2.04; 95% CI: 1.28-3.26). Dementia was associated with an increased odds of death (OR_{adj}: 6.36; 95% CI: 1.29-31.34) (Table 2). The presence of more than two comorbidities was associated with increased odds of death in patients on mechanical ventilation compared with no comorbidities (OR_{adj}: 2.12; 95% CI: 1.15-4.03) (Table 3).

4 | DISCUSSION

This is one of the initial studies including a population of the first and largest COVID-19 epicenter in the US with adequate follow-up time to report on risk factors associated with hospitalization, need for mechanical ventilation and mortality. In this large, retrospective cohort of COVID-19 positive patients in New York City, the main risk factors associated with hospitalization, need for mechanical ventilation and death were increasing age and male gender, confirming results of previous studies.[5,8,13,14] Although obesity was found to be a risk factor for hospitalization and need for mechanical ventilation, it was not associated with increased risk of death. The presence of certain comorbidities was associated with an increased risk for hospitalization in COVID-19 positive patients, however only diabetes and CHF were associated with increased risk of mechanical ventilation and death, respectively. Increased risk of mechanical ventilation and death was also associated with the presence of more than two comorbidities.

Hypertension was found to be the most prevalent comorbidity in this cohort of New York patients with COVID-19 corroborating previously published studies. Two Chinese studies reported that hypertension was most prevalent in 16.9% and 30% of their study populations consisting of laboratory-confirmed hospitalized patients.[8,19] Grasselli et al found that hypertension was the most prevalent comorbidity (49%) among laboratory-confirmed patients admitted to the ICU in Lombardy (Italy).[5] A recent meta-analysis reported that hypertension, respiratory disease and cardiovascular disease were associated with increased odds of severe disease.[12] A Chinese, retrospective cohort study reported that severe disease was independently associated with increased weight (BMI ≥ 28 kg/m^2) and a history of diabetes.[20] Another study similarly found that patients deceased from COVID-19 had a higher BMI than survivors, indicating that obesity is an important risk factor associated with higher mortality.[15] Although our results showed that COPD, diabetes, overweight, and obesity were associated with hospitalization, only diabetes and obesity (BMI > 30 kg/m^2) were independently associated with mechanical ventilation, indicating more severe disease. It was not possible to investigate the effect of pre-diagnosis treatment prescribed for the included medical conditions on COVID-19 outcomes as this information was not collected. A recently published study on pre-diagnosis anticoagulation or antiplatelet therapy was not associated with improved COVID-19 mortality.[21]

Dementia needs to be highlighted as it was associated with increased odds of hospitalization but, because patients with dementia are less likely to receive mechanical ventilation, dementia is associated with increased odds of death. People with dementia are at increased risk of contracting COVID-19 for several reasons, including the inability to follow recommendations from public health authorities to reduce disease transmission, monitoring/reporting symptoms, and self-isolating at home.[22,23] Additionally, people with dementia often need supportive living environments (nursing homes) in which social distancing is difficult to maintain, therefore further increasing the risk of infection.[22] Age is an established risk factor for both dementia and more severe COVID-19 and death.[22] Dementia is

also associated with multiple physical comorbidities, a risk factor for more severe disease. An additional risk factor associated with potentially more severe COVID-19 in patients with dementia is that hospitalization, a new environment, can lead to increased stress, behavioral problems, and delirium.[22,23] Another important factor affecting outcome is that many patients with dementia have "do not resuscitate" status. These patients therefore did not receive mechanical ventilation, which was shown by our data, resulting in poorer survival. A recent study additionally found that *ApoE e4e4* allele, a variant associated with increased risk of Alzheimer's disease, increased the risk of severe COVID-19 infection.[24]

The results showed no difference in hospitalization, need for invasive mechanical ventilation or death when comparing non-Hispanic White and non-Hispanic Black patients. Recent publications reported that African Americans are hospitalized more frequently within the United Sates. A report from the CDC found that 33% of patients hospitalized with COVID-19 were African American despite comprising only 18% of the surrounding community, suggesting that African Americans are disproportionally represented among hospitalized patients with COVID-19.[25] Likewise, a recent study in the US state of Georgia found that a higher proportion of African Americans were hospitalized with COVID-19 than would be expected based on overall hospital admissions.[26] However, they did not find race to be associated with higher ventilation rates or increased adverse clinical outcomes, corroborating the results of the present study.[27] Future studies investigating the role of race in hospital admission and COVID-19-related outcomes are needed.

A number of early reports from mainland China suggested that smoking was associated with increased severity of symptoms and higher rates of adverse outcomes among patients with COVID-19.[26] In contrast, our results found no association between current smokers and rates of hospitalization, need for invasive mechanical ventilation or death when compared with never-smokers. Interestingly, former smokers were less likely to be hospitalized compared with never-smokers, although there was no difference between the two groups in terms of need for invasive mechanical ventilation or death. These results are consistent with a number of recent publications that have found no evidence that smoking is a risk factor for more severe disease progression or adverse clinical outcomes in patients with COVID-19.[28,29]

Limitations of our study include that the study population only included patients within the New York metropolitan area therefore potentially limiting the generalizability of the results. This study was a retrospective study using data collected from the electronic medical health records of ambulatory and hospitalized COVID-19 positive patients. The increased patient volume and reduced time per patient associated with the increased influx of patients during the pandemic resulted in missing data, especially for ambulatory patients, on certain covariates including race, BMI, and smoking status. The reported smoking status in the electronic medical health records as well as comorbidities may also contain inaccuracies and is potentially underreported. Furthermore, it was not possible to collect mortality data for the patients who were still hospitalized at the time of data collection, therefore potentially introducing bias. However, it is likely that this introduced little bias because all patients had at least a follow-up time of 6 weeks and only 1.3% of the study population was still hospitalized at the time of data collection.

In conclusion, the main drivers of a worse prognosis, including need for mechanical ventilation and death, in COVID-19 positive patients are older age and male gender, while the presence of obesity and comorbidities were mainly associated with an increased need for hospitalization in this US cohort. Our results also indicated former smoking as a protective factor in terms of hospitalization, which should be further investigated. Patients infected with COVID-19 who have one or more of the identified risk factors associated with a worse outcome should be closely monitored.

ACKNOWLEDGMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

MG and DT conceived and designed the study. MG, MA, CL, JB, LN, and DT contributed to the data collection. MG, MA, and EG contributed to data analysis and data interpretation. MG, MA, and CL contributed to the literature search and writing of the manuscript. All authors contributed to the revision of the manuscript and approved final draft for publication.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

How to cite this article: van Gerwen M, Alsen M, Little C, et al. Risk factors and outcomes of COVID-19 in New York City; a retrospective cohort study. *J Med Virol*. 2021;93:907–915. https://doi.org/10.1002/jmv.26337