Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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COVID-19 outcomes of patients with gynecologic cancer in New York City: An updated analysis from the initial surge of the pandemic

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HIGHLIGHTS

- Gynecologic cancer patients with COVID-19 had a case fatality rate of 17.6% during the initial surge of the COVID-19 pandemic.
- Hospitalization due to COVID-19 was associated with age ≥ 65 years, Black race, performance status ≥2 and ≥ 3 comorbidities.
- Only former or current history of smoking \was associated with death due to COVID-19.
- Recent immunotherapy use was not associated with hospitalization or death due to COVID-19 infection.

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ABSTRACT

Background. Despite significant increase in COVID-19 publications, characterization of COVID-19 infection in patients with gynecologic cancer remains limited. Here we present an update of COVID-19 outcomes among people with gynecologic cancer in New York City (NYC) during the initial surge of severe acute respiratory syndrome coronavirus 2 (coronavirus disease 2019 [COVID-19]).

Methods. Data were abstracted from gynecologic oncology patients with COVID-19 infection among 8 NYC area hospital systems between March and June 2020. Multivariable logistic regression was utilized to estimate associations between factors and COVID-19 related hospitalization and mortality.

Results. Of 193 patients with gynecologic cancer and COVID-19, the median age at diagnosis was 65.0 years (interquartile range (IQR), 53.0–73.0 years). One hundred six of the 193 patients (54.9%) required hospitalization; among the hospitalized patients, 13 (12.3%) required invasive mechanical ventilation, 39 (36.8%) required ICU admission. Half of the cohort (49.2%) had not received anti-cancer treatment prior to COVID-19 diagnosis. No patients requiring mechanical ventilation survived. Thirty-four of 193 (17.6%) patients died of COVID-19 complications. In multivariable analysis, hospitalization was associated with an age ≥ 65 years (odds ratio [OR] 2.12, 95% confidence interval [CI] 1.11, 4.07), Black race (OR 2.53, CI 1.24, 5.32), performance status ≥2 (OR 3.67, CI 1.25, 13.55) and ≥ 3 comorbidities (OR 2.00, CI 1.05, 3.84). Only former or current history of smoking (OR 2.75, CI 1.21, 6.22) was associated with death due to COVID-19 in multivariable analysis. Administration of cytotoxic chemotherapy within 90 days of COVID-19 diagnosis was not predictive of COVID-19 hospitalization (OR 0.83, CI 0.41, 1.68) or mortality (OR 1.56, CI 0.67, 3.53).

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Conclusions. The case fatality rate among patients with gynecologic malignancy with COVID-19 infection was 17.6%. Cancer-directed therapy was not associated with an increased risk of mortality related to COVID-19 infection.

1. Introduction

New York City (NYC) has been a major epicenter of the pandemic caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2 (coronavirus disease 2019 [COVID-19])). Since the onset of this public health crisis, patients with cancer have been assumed to be at higher risk for severe COVID-19 infection and related death. Early reports suggested increased risk of contracting the virus and developing COVID-19 related complications in patients with cancer [1–3]. However, these findings were limited by their heterogeneity, small sample size, lack of generalizability to all cancer types and limited comparisons to cohorts without cancer.

Multi-institutional studies published early in the pandemic showed case fatality rates from 11 to 28% in patients with cancer and 21% among the general population of patients with COVID-19 infection [4–7]. Subset analyses reveal varied mortality rates among cancer types, which the highest mortality seen in patients with lung cancer (55%) [6]. More recent studies continue to show that the overall fatality rate of COVID-19 patients with cancer is higher than COVID-19 patients without cancer (22.4% vs 5.9%) [8]. While more in depth analysis have shown patients with leukemia, non-Hodgkin lymphoma, and lung cancer have the high increased risk of COVID-19 infection [9].

Notably, patients with gynecologic cancer are underrepresented in these larger studies. Our initial study of patients with gynecologic cancer and COVID-19 infection revealed a case fatality rate of 14%, and revealed no association between cytotoxic chemotherapy or cancer-directed surgery and COVID-19 severity or death. However, immunotherapy was noted to increase risk of mortality in our limited sample size of patients with gynecologic cancer and COVID-19 infection [10]. Given these initial observations of anti-cancer treatment use in patients with gynecologic cancer, specifically immunotherapy, the objective of this study is to provide additional insight into continued cancer-directed therapy in a larger cohort of patients. The primary objective of this multi-institutional study is to explore the relationship between COVID-19 severity in a cohort of patients with both gynecologic cancer and COVID-19. Furthermore, we provide updated clinical and cancer characteristics associated with hospitalization and fatality due to COVID-19.

2. Methods

2.1. Study population

We conducted a multi-institutional, retrospective, observational cohort study at 8 NYC area hospital systems. The study was approved by the institutional review board at each site. Patients 18 years or older with gynecologic malignancy and confirmed SARS-CoV-2 infection from March 1, 2020 and June 1, 2020 (initial surge in NYC) were included. SARS-CoV-2 infection was defined as: a positive result with a real-time reverse transcriptase-polymerase chain reaction assay on a nasopharyngeal swab; serologic confirmation of SARS-CoV-2; or a diagnosis based on radiologic imaging by chest radiograph or chest computed tomography [11]. All included subjects were de-identified prior to data review.

2.2. Data collection

Clinical data were abstracted from the electronic medical record (EMR) for all patients meeting inclusion criteria using Research Electronic Data Capture (REDCap) software (Vanderbilt University) [12,13]. Patient characteristics included age, self-reported race and ethnicity, medical comorbidities, Eastern Cooperative Oncology Group (ECOG) performance status [14], severity of COVID-19 infection, cancer type, stage of diagnosis, current cancer disease status, and recent anti-cancer treatment. Recent anti-cancer treatment was defined as treatment within 90 days of COVID-19 diagnosis. Clinical COVID-19 related characteristics include symptoms of COVID-19, vital signs at admission, inpatient complications due to COVID-19, and need for supplemental oxygen including invasive mechanical ventilation.

2.3. Outcome measures

Our primary outcomes were hospitalization due to COVID-19 infection and COVID-19 related mortality. Hospitalization due to COVID-19 was stratified by COVID-19 severity, grouped as mild for cases managed on an outpatient basis and moderate or severe for cases requiring hospitalization. Severe COVID-19 cases were defined as COVID-19 infection requiring ICU admission, invasive mechanical ventilation, or resulting in COVID-19 related mortality. COVID-19 related mortality was defined as patients who died of COVID-19 related complications and not due to their cancer.

2.4. Statistical analysis

Descriptive statistics were calculated for demographic, cancer-related, and COVID-19-related characteristics by COVID-19 severity. Continuous variables were described as medians with interquartile ranges (IQR) and compared between groups using the Wilcoxon rank-sum test. Categorical variables were presented as frequencies and proportions and compared between groups using the Chi-square tests. Hospitalization and mortality rates were calculated for the overall population. Multivariable logistic models included factor age (less than or equal to 65 and greater than 65 years), race (black vs other), smoking status (never vs. former/current), performance status (score of 0–1 vs. 2–3), number of comorbidities (0–2 vs. 3 or more), and current cytotoxic chemotherapy treatment (no vs. yes) based on knowledge if they were known risk factors for COVID-19 infection (age, race, performance status and comorbidities) or over 10% differences between survivors and non-survivors. For missing covariate values, 5 cases with unknown smoking status were classified into the 'never' group, 18 cases with unknown performance status were classified into '0–1' group. Odds ratios (OR) and 95% confidence intervals (CIs) were reported for all multivariable logistic regression models. Statistical analyses were performed using R version 4.0.1 (https://cran.r-project.org/). All statistical tests were two-sided, and a P-value <0.05 was considered statistically significant.

3. Results

3.1. Baseline characteristics of patients

Overall, data from 193 patients from 8 New York City area hospitals were analyzed. Baseline demographics are shown in Table 1. The median age was 65 years [IQR 53,73 years] 46.6% were White and 34.7% were Black. Despite White patients comprising the majority, a higher percentage of Black patients compared to White patients required hospitalization for COVID-19 management (71.6% [48/67] vs 48.9% [44/90]). A total of 49 patients (25.4%) were current or former smokers. A higher percentage of patients who reported former or current smoking

Table 1
Baseline demographics.

		Disease Severity		
	Overall	Mild	Moderate	Severe
Characteristic	193	87	67	39
Age, median (IQR), y	65 [54, 73]	60 [51, 70]	67 [59, 74]	69 [61, 75]
Race, No. (%)				
White	90 (46.6)	46 (52.9)	26 (38.8)	18 (46.2)
Black/African American	67 (34.7)	19 (21.8)	33 (49.3)	15 (38.5)
Other	36 (18.7)	22 (25.3)	8 (11.9)	6 (15.4)
Hispanic ethnicity, No. (%)	39 (20.2)	21 (24.1)	9 (13.4)	9 (23.1)
Smoking history, No. (%)				
Current Smoker	9 (4.7)	3 (3.4)	2 (3.0)	4 (10.3)
Former smoker	40 (20.7)	14 (16.1)	12 (17.9)	14 (35.9)
Never Smoker	144 (74.6)	70 (80.5)	53 (79.1)	21 (53.8)
Comorbidities, No. (%)				
<3	107 (55.4)	60 (68.9)	31 (46.3)	16 (41.0)
≥3	86 (44.6)	27 (31.0)	36 (53.7)	23 (59.0)
Comorbidities, No. (%)				
Hypertension	115 (59.6)	41 (47.1)	45 (67.2)	29 (74.4)
Diabetes mellitus	70 (36.3)	21 (24.1)	30 (44.8)	19 (48.7)
Coexisting malignancies	21 (10.9)	10 (11.5)	3 (4.5)	8 (20.5)
Asthma	21 (10.9)	6 (6.9)	9 (13.4)	6 (15.4)
COPD	5 (2.6)	1 (1.1)	2 (3.0)	2 (5.1)
Obstructive sleep apnea	12 (6.2)	2 (2.3)	6 (9.0)	4 (10.3)
Coronary artery disease	13 (6.7)	3 (3.4)	5 (7.5)	5 (12.8)
Autoimmune disease	18 (9.3)	8 (9.2)	5 (7.5)	5 (12.8)
Chronic kidney disease	21 (10.9)	3 (3.4)	9 (13.4)	9 (23.1)
Body mass index, mean (SD), kg/m2	31.65 (9.13)	29.97 (7.51)	33.73 (9.33)	31.72 (11.28)
Performance status, No. (%)				
0–1	148 (76.7)	77 (88.5)	48 (71.6)	23 (59.0)
≥2	27 (14.0)	4 (4.6)	12 (17.9)	11 (28.2)
Unknown	18 (9.3)	6 (6.9)	7 (10.4)	5 (12.8)
History of sick contacts, No. (%)	60 (31.1)	29 (33.3)	21 (31.3)	10 (25.6)
Symptoms, No. (%)				
Fever	99 (51.3)	37 (42.5)	42 (62.7)	20 (51.3)
Cough	94 (48.7)	35 (40.2)	43 (64.2)	16 (41.0)
Shortness of breath	73 (37.8)	8 (9.2)	38 (56.7)	27 (69.2)
Anosmia	9 (4.7)	8 (9.2)	1 (1.5)	0 (0.0)
Sore throat	11 (5.7)	7 (8.0)	3 (4.5)	1 (2.6)
Headache	12 (6.2)	9 (10.3)	3 (4.5)	0 (0.0)
Nausea or vomiting	26 (13.5)	8 (9.2)	10 (14.9)	8 (20.5)
Diarrhea	33 (17.1)	11 (12.6)	14 (20.9)	8 (20.5)
Myalgias	30 (15.5)	13 (14.9)	11 (16.4)	6 (15.4)
Anorexia	7 (3.6)	5 (5.7)	2 (3.0)	0 (0.0)
Asymptomatic	28 (14.5)	25 (28.7)	2 (3.0)	1 (2.6)

use required hospitalization compared to non-smokers (65.3% [32/49] vs 51.4% [74/144]).

There were 86 (44.6%) patients with three or more comorbidities. Patients with three or more coexisting illnesses were more likely to require hospitalization (55.7% [59 /106] vs 44.3% [47 of 106]; $P = 0.002$). The most common comorbidity was hypertension (115, 59.6%), followed by diabetes mellitus (70, 36.3%), coexisting malignancies (21, 10.9%), asthma (21, 10.9%) and chronic kidney disease (21, 10.9%). The majority of patients had an ECOG performance status of 0 to 1 (76.7%). Twenty-seven patients had an ECOG performance status of 2 or greater, of which 24 (88.9%) required hospitalization. The most common presenting symptoms of fever (99, 51.3%), cough (94, 48.7%) and shortness of breath (73, 37.8%) were all associated with COVID-19 severity and risk of hospitalization (P values <0.05).

3.2. Cancer characteristics of patients

A wide distribution of gynecologic cancer types was seen in the cohort (Table 2). The most commonly represented cancer types were uterine (87, 45.1%), epithelial ovarian (62, 32.1%), and cervical carcinoma (24, 12.4%). One hundred of 193 (51.8%) patients presented with advanced stage disease. In the group, 50.8% (98 of 193) patients had received cancer directed therapy within 90 days of COVID-19 diagnosis. The most common therapy received was chemotherapy (57, 29.5%) followed by targeted therapy (19, 9.8%) and cancer-directed surgery (12, 6.2%). Of patients who were hospitalized 28.3% [30 of 106] received chemotherapy, 4.7% [5 of 106) underwent surgery and 5.6% [6 of 106] received either immunotherapy, targeted therapy or hormonal therapy in ninety days preceding COVID-19 diagnosis.

3.3. Factors associated with COVID-19 hospitalization and mortality

106 out of 193 patients (54.9%) required hospitalization (Table 3). Among hospitalized patients 90 (84.9%) presented from home. Upon hospitalization, 72.6% (77 of 106) of patients required respiratory intervention. The majority of patients required oxygen via nasal cannula (30, 28.3%), non-rebreather (17, 16.0%) or high flow nasal cannula (17, 16.0%). Invasive mechanical ventilation was required in 12.3% (13 of 106) of patients. No patient requiring invasive ventilation survived. The most common complications secondary to COVID-19 infection were pulmonary, cardiovascular and renal. Table 4 shows the distribution of demographic and cancer characteristics among hospitalized and non-hospitalized patients along with the between group differences and 95% CIs. Hospitalized patients were older (66.2 years for hospitalized vs 59.1 years for non-hospitalized), more often of Black race, and more commonly had three or more comorbidities with a performance status greater than 2 (55.7% vs. 31.0%, difference 24.6 [38.9, 10.3]). Among hospitalized patients, no differences were seen in distribution of patients with respect to cancer status (5.7 [−8.9, 20.2]) or types of cancer-directed therapy.

There were a total of 39 patients who developed severe COVID-19 infections of which 34 (87.2%) died. The case fatality rate among patients with gynecologic cancer with COVID-19 was 17.6%. Of patients who died, 13 (38.2% [13 of 34]) had received chemotherapy while 4 (11.8% [4 of 34]) had received immunotherapy within 90 days of COVID-19 diagnosis. (Fig. 1). Group differences among survivors and non-survivors can be seen in Table 4. Patients who died were more likely to be older, Black, former or current smokers, have 3 or more comorbidities, and have recently received chemotherapy.

Multivariable analyses were performed to account for the associations between factors and risk of hospitalization or COVID-19-related death (Table 5). Patient who were 65 years or older had 2.12 fold greater risk (OR) of hospitalization (95% CI, 1.11, 4.07). Similarly Black race (2.53, 95%CI [1.24, 5.32]), performance status ≥2 (3.67, 95%CI [1.25, 13.55]), and ≥3 comorbidities (2.00, 95%CI [1.05, 3.84]) were all associated with increased risk of hospitalization.

In multivariable analysis specific to COVID-19-related mortality, only former or current smoking use increased the risk of death over 2-fold (2.75, 95%CI [1.21, 6.22]). Age, race, comorbidities, chemotherapy use, and performance status were not associated with death in the multivariable model.

4. Discussion

In our updated analysis of 193 patients with gynecologic malignancy and COVID-19, we examined the baseline demographics, cancer characteristics and determinants of COVID-19 severity and mortality. Over 50% of patients with gynecologic malignancy and COVID-19 required hospitalization. Similar to what has been described in the literature, age, Black race, poorer performance status and presence of three or more comorbidities was associated with increased need for hospitalization due to COVID-19 [4,15–17].

The overall mortality among our cohort of COVID-19 infected patients was 17.6%. In the multivariable analysis, only smoking habits maintained a significant association with death. Thirty nine of 193

Table 2
Cancer characteristics.

		Disease Severity		
	Overall	Mild	Moderate	Severe
Characteristic	193	87	67	39
Cancer type, No. (%)				
Uterine	87 (45.1)	34 (39.0)	36 (53.7)	17 (43.6)
Epithelial ovarian carcinoma	62(32.1)	31 (35.6)	15 (22.4)	16 (41.0)
Cervical carcinoma	24 (12.4)	10 (11.5)	10 (14.9)	4 (10.3)
Vulvar carcinoma	8 (4.1)	7 (8.0)	1 (1.5)	0 (0.0)
Non-Epithelial ovarian carcinoma	6 (3.1)	1 (1.1)	3 (4.4)	2 (5.1)
Gestational trophoblastic disease	3 (1.6)	2 (2.3)	1 (1.5)	0 (0.0)
Vaginal carcinoma	2 (1.0)	1 (1.1)	1 (1.5)	0 (0.0)
Stage, No. (%)				
I/II	74 (38.3)	35 (40.2)	25 (37.3)	14 (35.9)
III/IV	100 (51.8)	49 (56.3)	30 (44.8)	21 (53.8)
Unknown	19 (9.8)	3 (3.4)	12 (17.9)	4 (10.3)
Cancer status, No. (%)				
Remission	77 (39.9)	32 (36.8)	31 (46.3)	14 (35.9)
Evidence of disease	116 (60.1)	55 (63.2)	36 (53.7)	25 (64.1)
Currently undergoing treatment for cancer, No. (%)				
Initial cancer therapy	40 (20.7)	21 (24.1)	13 (19.4)	6 (15.4)
Treatment for recurrence	39 (20.2)	19 (21.8)	10 (14.9)	10 (25.6)
Noncurative/palliative therapy	12 (6.2)	4 (4.6)	6 (9.0)	2 (5.1)
Maintenance therapy	7 (3.6)	6 (6.9)	1 (1.5)	0 (0.0)
Unknown/no therapy	95 (49.2)	37 (42.5)	37 (55.2)	21 (53.8)
Most recent anticancer treatment, No. (%)				
Surgery	12 (6.2)	7 (8.0)	3 (4.5)	2 (5.1)
Cytotoxic chemotherapy	57 (29.5)	27 (31.0)	17 (25.4)	13 (33.3)
Immunotherapy	11 (5.7)	5 (5.7)	2 (3.0)	4 (10.3)
Targeted therapy	19 (9.8)	13 (14.9)	4 (6.0)	2 (5.1)
Hormone therapy	11 (5.7)	5 (5.7)	5 (7.5)	1 (2.6)
Radiotherapy	8 (4.1)	5 (5.7)	3 (4.5)	0 (0.0)

(20%) of patients developed severe COVID-19 infection requiring ICU admission. Of these patients, 13 required intubation. Similar to our previous report, no patients requiring intubation survived, which can be informative when counseling patients with severe COVID-19 infection.

Our data shows that while 50% of patients that required hospitalization were receiving cancer-directed therapy, even the most common therapy (cytotoxic chemotherapy), did not affect hospitalization or mortality in patients with COVID-19 on multivariable analysis. Despite initial report of increased mortality for patient with gynecologic cancer and COVID-19 who were receiving immunotherapy, immunotherapy was not associated with an increased risk of death due to COVID-19 in this expanded cohort. However, we do acknowledge our small study cohort, and the need for large scale registries to define risk of cancer disease status and recent therapeutics in greater detail. This is particularly important because recent immunotherapy use has been linked to increased risk of COVID-19 mortality in cancer patients, specifically lung cancer compared to any other malignances [18].

Our data demonstrate that in patients with gynecologic cancer, the risk of severe COVID-19 outcomes is largely driven by age, race, and comorbidities. This corresponds with recent literature, where numerous studies have identified important demographic and clinical factors that increase risk of COVID-19 severity in the non-cancer population. Age is one of the most important risk factors for COVID-19 severity, and one meta-analysis demonstrated an exponential relationship between age and COVID-19 mortality rates, increasing from 0.01% at age 25, to 1.4% at age 65 and 15% at age 85 [19]. In our patient cohort, the median age at the time of COVID-19 diagnosis was 65 years and those over 65 years had two times greater risk of hospitalization. There is also robust evidence that pre-existing conditions, such as cardiovascular disease, chronic kidney disease, chronic lung conditions, diabetes mellitus, hypertension, and obesity predispose patients to more severe COVID-19 outcomes [20–25]. According to an American College of Cardiology clinical bulletin, COVID-19 fatality rates are 10.5% for patients with cardiovascular disease, 7.3% for diabetes, 6.3% for COPD, and 6.0% for hypertension, compared to <1% for patients without pre-existing conditions [20]. In our patient cohort, 45% of patients who had three

Table 3
Characteristics of hospitalized patients.

		Disease Severity	
	Overall	Moderate	Severe
Characteristic	106	67	39
Admitted from, No. (%)			
Home	90 (84.9)	58 (86.6)	32 (82.1)
Skilled nursing facility/rehab	10 (9.4)	5 (7.5)	5 (12.8)
Hospital Transfer	3 (2.8)	2 (3.0)	1 (2.6)
Other	3 (2.8)	2 (3.0)	1 (2.6)
Vital signs on ED admission, median (IQR)			
Temperature, median (IQR), °F	99 [98, 100]	99 [98, 100]	98 [98, 100]
Heart rate, beats/min	104 [85, 116]	101 [82, 112]	109 [95, 118]
Respiratory rate, breaths/min	20 [18, 24]	20 [18, 24]	21 [20, 24]
Oxygen saturation, %	94 [91, 97]	94 [91, 98]	94 [80, 96]
Highest level of respiratory intervention, No. (%)			
Nasal cannula	30 (28.3)	26 (38.8)	4 (10.3)
Non-rebreather	17 (16.0)	11 (16.4)	6 (15.4)
High-flow nasal cannula	13 (12.3)	5 (7.5)	8 (20.5)
BiPAP	4 (3.8)	0 (0.0)	4 (10.3)
Invasive mechanical ventilation	13 (12.3)	0 (0.0)	13 (33.3)
Complications, No. (%)			
Multiorgan failure	9 (8.5)	0 (0.0)	9 (23.1)
Pulmonary complications	66 (62.3)	33 (49.3)	33 (84.6)
Cardiovascular complications	16 (15.1)	3 (4.5)	13 (33.3)
Renal failure	21 (19.8)	8 (11.9)	13 (33.3)
Sepsis	12 (11.3)	4 (6.0)	8 (20.5)
Bleeding	3 (2.8)	3 (4.5)	0 (0.0)
Treatments, No. (%)			
Chloroquine	1 (0.5)	1 (1.5)	0 (0.0)
Hydroxychloroquine	53 (27.5)	32 (47.8)	19 (48.7)
Azithromycin	47 (24.4)	25 (37.3)	18 (46.2)
Corticosteroids	6 (3.1)	2 (3.0)	3 (7.7)
Tocilizumab	3 (1.6)	3 (4.5)	0 (0.0)
Plasma from recovered individuals	5 (2.6)	3 (4.5)	2 (5.1)
Anticoagulation	19 (9.8)	9 (13.4)	9 (23.1)
Clinical outcome at data cutoff, No. (%)			
Fully recovered	48 (45.3)	47 (70.1)	1 (2.6)
Recovered with complications	14 (13.2)	12 (17.9)	2 (5.1)
Ongoing infection	10 (9.4)	8 (11.9)	2 (5.1)
Died of COVID-19 related complications	34 (32.1)	0 (0.0)	34 (87.2)

Table 4
Demographic and cancer characteristics among hospitalized patients and survivors of COVID-19.

	Not Hospitalized	Hospitalized	Difference (95% CI)	Survivors	Nonsurvivors	Difference (95% CI)
Age, mean ± SD, y	59.1 ± 13.4	66.2 ± 11.6	−7.1 (−10.7, −3.5)	61.9 ± 13.0	68.1 ± 11.6	−6.2 (−10.7, −1.7)
Race, %						
White	52.9	41.5	11.4 (−3.4, 26.1)	47.2	44.1	3.1 (−11.7, 17.9)
Black	21.8	45.3	−23.4 (−37.1, −9.8)	33.3	41.2	−7.8 (−22.2, 6.5)
Other	25.3	13.2	12.1 (0.3, 23.9)	19.5	14.7	4.8 (−6.6, 16.2)
Hispanic ethnicity, %	24.1	17	7.2 (−5.0, 19.3)	19.5	23.5	−4.0 (−16.4, 8.3)
Smoking history, %						
Current Smoker	3.4	5.7	−2.2 (−9.0, 4.6)	3.1	11.8	-8.6 (−16.8, −0.4)
Former smoker	16.1	24.5	−8.4 (−20.5, 3.7)	18.2	32.4	−14.1 (−27.0, −1.2)
Never Smoker	80.5	69.8	10.6 (−2.2, 23.5)	78.6	55.9	22.7 (9.1, 36.4)
Comorbidities, %						
Hypertension	47.1	69.8	−22.7 (−37.0, −8.4)	56.6	73.5	−16.9 (−30.9, −2.9)
Diabetes mellitus	24.1	46.2	−22.1 (−36.0, −8.2)	34	47.1	−13.1 (−27.6, 1.4)
Coexisting malignancies	11.5	10.4	1.1 (−8.5, 10.8)	8.8	20.6	−11.8 (−22.5, −1.1)
Asthma	6.9	14.2	−7.3 (−16.7, 2.2)	10.7	11.8	−1.1 (−10.8, 8.7)
Chronic obstructive pulmonary disease	1.1	3.8	−2.6 (−7.9, 2.7)	1.9	5.9	−4.0 (−10.3, 2.3)
Obstructive sleep apnea	2.3	9.4	−7.1 (−14.6, 0.3)	5	11.8	−6.7 (−15.4, 1.9)
Coronary artery disease	3.4	9.4	−6.0 (−13.7, 1.8)	5.7	11.8	−6.1 (−14.9, 2.7)
Autoimmune disease	9.2	9.4	−0.2 (−8.5, 8.1)	8.2	14.7	−6.5 (−16.3, 3.2)
Chronic kidney disease	3.4	17	−13.5 (−22.7, −4.4)	8.8	20.6	−11.8 (−22.5, −1.1)
Comorbidities: ≥3, %	31	55.7	−24.6 (−38.9, −10.3)	41.5	58.8	−17.3 (−32.0, −2.7)
Body mass index, mean ± SD, kg/m2	30.0 ± 7.5	33.0 ± 10.1	−3.0 (−5.6, −0.5)	31.6 ± 8.4	32.1 ± 12.0	−0.6 (−5.0, 3.9)
Performance status ≥2, %	4.6	21.7	−17.1 (−27.2, −7.0)	10.7	29.4	−18.7 (−30.5, −6.9)
Stage III/IV, %	56.3	48.1	8.2 (−6.6,23.0)	50.9	55.9	−4.9 (−19.7, 9.9)
Cancer status, Active disease, %	63.2	57.5	5.7 (−8.9,20.2)	58.5	67.6	−9.2 (−23.5, 5.2)
Currently undergoing treatment for cancer, %						
Initial cancer therapy	24.1	17.9	6.2 (−6.0,18.5)	21.4	17.6	3.7 (−8.2,15.7)
Treatment for recurrence	18.4	17.9	0.5 (−10.7, 11.6)	17	23.5	−6.5 (−18.7, 5.6)
Noncurative/palliative therapy	4.6	7.5	−2.9 (−10.6, 4.7)	6.3	5.9	0.4 (−6.6, 7.4)
Maintenance therapy	6.9	0.9	6.0 (−0.4,12.3)	4.4	0	4.4 (−0.6, 9.4)
Most recent anticancer treatment, %						
Surgery	8	4.7	3.3 (−4.4,11.1)	6.3	5.9	0.4 (−6.6, 7.4)
Cytotoxic chemotherapy	31	28.3	2.7 (−10.9, 16.4)	27.7	38.2	−10.6 (−24.5, 3.4)
Immunotherapy	5.7	5.7	0.1 (−6.4, 6.6)	4.4	11.8	−7.4 (−15.8, 1.1)
Targeted therapy	14.9	5.7	9.3 (0.0,18.6)	11.3	2.9	8.4 (0.3,16.4)
Hormone therapy	5.7	5.7	0.1 (−6.4, 6.6)	6.3	2.9	3.3 (−3.4,10.1)
Radiotherapy	5.7	2.8	2.9 (−3.7, 9.5)	5	0	5.0 (−0.3,10.3)
History of surgery in last 60 d, %	21.8	12.3	9.6 (−1.8,20.9)	15.7	20.6	−4.9 (−16.5, 6.8)

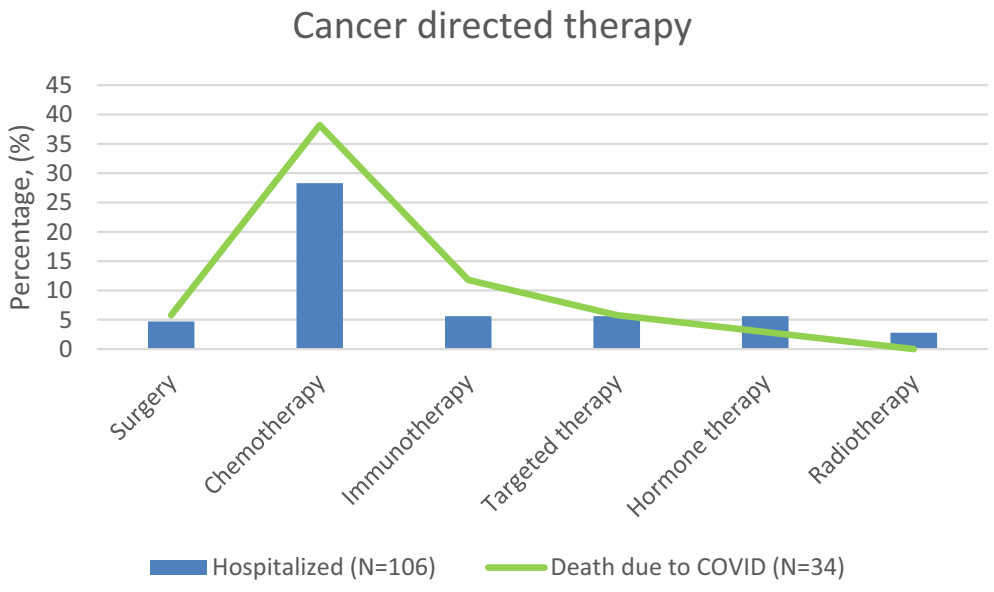

Fig. 1. Percent of patients who received cancer-directed therapy within 90 days prior to COVID diagnosis.

Table 5
Multivariate analyses for risk of COVID-19 related hospitalization and mortality.

	Hospitalization		Mortality	
Exposure Variable	OR	95% CI	OR	95% CI
Age: 65 years old or older	2.12	(1.11, 4.07)	1.74	(0.75, 4.14)
Black/African American	2.53	(1.24, 5.32)	1.20	(0.50, 2.85)
Other race	0.80	(0.33, 1.92)	0.92	(0.26, 2.88)
Performance status: ≥2	3.67	(1.25, 13.55)	2.59	(0.96, 6.80)
Comorbidities: ≥3	2.00	(1.05, 3.84)	1.51	(0.67, 3.42)
History of smoking	1.65	(0.80, 3.49)	2.75	(1.21, 6.22)
Cytotoxic chemotherapy*	0.83	(0.41, 1.68)	1.56	(0.67, 3.53)

* Cytotoxic chemotherapy administered within 90 days of COVID-19 diagnosis.

or more comorbidities and were more likely to require hospitalization for COVID-19.

Initial studies reporting COVID-19 outcomes suggested patients with cancer harbored a 2-fold higher risk of COVID-19 infection compared with the community [1,26]. Patients with lung cancer were found to be of higher risk of developing COVID-19 representing the majority of cancer patients in these single institution studies. Additionally, these studies found fewer than half of patients with cancer had received cancer-directed therapy prior to developing COVID-19 offering limited insight into continuing cancer therapy.

Subsequent studies have yielded contradictory results. A single institution study from NYC of 5688 patients of which 6% had cancer revealed the rate of death between cancer and noncancer patients was not significantly different [27]. In the largest cohort of 800 patients with cancer, which included only 45 patients with gynecologic cancers, recent chemotherapy use was not significantly associated with increased mortality. No association between recent immunotherapy, hormonal therapy, targeted therapy or radiotherapy and COVID-19 mortality was observed [28]. These results are in line with our findings that COVID-19 mortality in patients with cancer is largely driven by age, and the presence of comorbidities.

Our analysis has a number of limitations. Our outcomes are based on data collected during the first wave of the COVID-19 pandemic in NYC. Given our limited testing capabilities at this time we likely under captured a subset of patients with asymptomatic or mild infections who were not tested; thus, we may have overestimated the rate of hospitalization and mortality due to COVID-19. Hospital admission criteria varied between institutions, which is also a limitation of this study. Additionally, we examined outcomes in patients who were largely symptomatic who sought help through established care, biasing our outcomes further. By limiting our data collection to the first months of the pandemic we did not evaluate the effect of recent treatment modalities, including monoclonal antibodies, on the course of COVID-19 infection. Finally, with our small sample size we were unable to identify determinants of mortality. The ongoing Society of Gynecologic Oncology COVID-19 registry will help to establish a larger sample size to confirm the generalizability of our results. Finally, our findings also represent data prior to the implementation of COVID-19 vaccinations. As widespread vaccinations become available, we must continue to obtain additional data to inform recommendations in patients with gynecologic malignancies.

Despite these limitations, our study represents data collected from 8 academic hospital systems across NYC. These data include outcomes of both private and public hospitals in a high COVID-19 burden area. Additionally, the population served by these institutions is racially and ethnically diverse and has provided data on racial disparities in patients with COVID-19 and gynecologic malignancy [29].

In summary, this study highlights that in patients with gynecologic malignancy and COVID-19 neither their cancer burden, nor cancer-directed therapy were associated with COVID-19 severity. Importantly we found in this cohort, immunotherapy was not associated with COVID-19 severity or mortality. These findings should allow clinicians to make informed decisions on continuing cancer-directed therapy as the pandemic continues.

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Author contributions

O.D.L., M.S., and B.P. contributed to the study design, acquired and analyzed data, generated figures, and wrote the manuscript. R.OC., C.C., S.V.B., E.C.D., V.K.., A.K., J.E., L.G., S.C., J.F., Y.L., contributed to data acquisition. Y.W. and M.L. performed statistical analysis. R.OC, J.W., S.V.B. and S.I. provided intellectual input. All authors contributed to the interpretation of data, vouched for the data analysis, contributed to the editing of the manuscript, and agreed to publication of this study.

Declaration of Competing Interest

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