Clinical Characteristics, Racial Inequities, and Outcomes in Patients with Breast Cancer and COVID-19: A COVID-19 and Cancer Consortium (CCC19) Cohort Study

BRIEF TITLE: COVID-19 and Breast Cancer

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ABSTRACT

Background: Limited information is available for patients with breast cancer (BC) and coronavirus disease 2019 (COVID-19), especially among underrepresented racial/ethnic populations.

Methods: This is a COVID-19 and Cancer Consortium (CCC19) registry-based retrospective cohort study of females with active or history of BC and laboratory-confirmed severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection diagnosed between March 2020 and June 2021 in the US. Primary outcome was COVID-19 severity measured on a five-level ordinal scale, including none of the following complications, hospitalization, intensive care unit admission, mechanical ventilation, and all-cause mortality. Multivariable ordinal logistic regression model identified characteristics associated with COVID-19 severity.

Results: 1,383 female patient records with BC and COVID-19 were included in the analysis, the median age was 61 years, and median follow-up was 90 days. Multivariable analysis revealed higher odds of COVID-19 severity for older age (aOR per decade, 1.48 [95% CI, 1.32 – 1.67]); Black patients (aOR 1.74; 95 CI 1.24-2.45), Asian Americans and Pacific Islander patients (aOR 3.40; 95 CI 1.70 – 6.79) and Other (aOR 2.97; 95 CI 1.71-5.17) racial/ethnic groups; worse ECOG performance status (ECOG PS ≥2: aOR, 7.78 [95% CI, 4.83 – 12.5]); pre-existing cardiovascular (aOR, 2.26 [95% CI, 1.63 – 3.15])/pulmonary comorbidities (aOR, 1.65 [95% CI, 1.20 – 2.29]); diabetes mellitus (aOR, 2.25 [95% CI, 1.66 – 3.04]); and active and progressing cancer (aOR, 12.5 [95% CI, 6.89 – 22.6]). Hispanic ethnicity, timing and type of anti-cancer therapy modalities were not significantly associated with worse COVID-19 outcomes. The total all-cause mortality and hospitalization rate for the entire cohort was 9% and 37%, respectively however, it varied according to the BC disease status.

Conclusions: Using one of the largest registries on cancer and COVID-19, we identified patient and BC related factors associated with worse COVID-19 outcomes. After adjusting for baseline characteristics, underrepresented racial/ethnic patients experienced worse outcomes compared to Non-Hispanic White patients.

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ABBREVIATIONS:

CCC19: Cancer and COVID-19 Consortium

COVID-19: Coronavirus disease 2019

BC: Breast Cancer

SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus-2

NHW: Non-Hispanic White

AAPI: Asian Americans and Pacific Islanders

ECOG PS: Eastern Cooperative Oncology Group performance status

HR: Hormone receptor

HER2: Human epidermal growth factor receptor 2

CDK 4/6 inhibitor: Cyclin-dependent kinase 4/6 inhibitor

NED: No evidence of disease

MBC: Metastatic breast cancer

INTRODUCTION

The COVID-19 pandemic has had a devastating impact worldwide and within the United States (U.S.).[1], [2] Previous studies have reported that patients with cancer are at an increased risk for SARS-CoV-2 infection and have higher rates of adverse outcomes with mortality rates ranging from 14% to 33%.[3]–[10] COVID-19 has also highlighted the long-standing health inequities in the U.S, as underrepresented racial and ethnic populations have disproportionately been affected. Some studies have reported non-White race/ethnicity to be an independent risk factor for worse COVID-19 outcomes such as hospitalization and death.[3], [6], [11]–[20] Recently published data from CCC19 also showed that Black patients with cancer experienced worse COVID-19 outcomes compared to White patients after adjusting for key risk factors including cancer status and comorbidities.[21]

Breast cancer (BC) is the most common cancer diagnosed in females and affects all major racial/ethnic groups.[22]–[24] There are well described racial/ethnic differences in BC incidence and outcomes in females in the U.S attributable to multiple social and biological factors.[25]–[27] Few studies have specifically evaluated the impact of COVID-19 in patients with BC; interpretation from prior studies has been limited by small sample sizes.[28], [29] Data specifically on the impact of COVID-19 among underrepresented racial/ethnic groups with BC are also lacking. Understanding the sociodemographic and clinical factors associated with higher risk for adverse COVID-19 outcomes will help guide patient care. Hence, we aimed to evaluate the prognostic factors, racial disparities, interventions, complications, and outcomes among patients with active or previous history of BC diagnosed with COVID-19.

METHODS

Study population

The COVID-19 and Cancer Consortium (CCC19) consists of 129 member institutions capturing granular, detailed, and uniform data on demographic and clinical characteristics, treatment information, and outcomes of COVID-19. Details of CCC19 protocol, data collection, and quality assurance have been previously described.[30], [31] This registry-based retrospective cohort study included all female adults (age≥18 years) with an active or previous history of invasive BC and laboratory-confirmed diagnosis of SARS-CoV-2 by polymerase chain reaction (PCR) and/or serology from March 17, 2020, to June 16, 2021 in the United States. Patient records with multiple invasive malignancies including history of multiple

invasive BC were excluded; patients with unknown or missing race and ethnicity, inadequate data quality (quality score>4) and those not evaluable for the primary ordinal outcome were also excluded (*supplementary appendix*).[31] This study was exempt from institutional review board (IRB) review (VUMC IRB#200467) and was approved by IRBs at participating sites per institutional policy. CCC19 registry is registered on ClinicalTrials.gov, NCT04354701.

Outcome definitions

The primary outcome was a five-level ordinal scale of COVID-19 severity based on each individual patient's most severe reported disease status: none of the following complications (0); admitted to the hospital; admitted to an intensive care unit (ICU); mechanically ventilated at any time after COVID-19 diagnosis; or death from any cause. Other COVID-19 related complications (cardiovascular; gastrointestinal; and pulmonary complications, acute kidney injury, multisystem organ failure, superimposed infection, sepsis, any bleeding); 30-day mortality; and anti-COVID-19 directed interventions (supplemental oxygen, remdesivir, systemic corticosteroids, hydroxychloroquine, and other treatments) are also reported.

Covariates

Covariates were selected *a priori* and included: age; sex; race/ethnicity (Non-Hispanic White [NHW], Black, Hispanic, Asian Americans and Pacific Islanders [AAPI], and Other) as recorded in the EHR, based on the Center for Disease Control and Prevention Race and Ethnicity codes[32]; U.S census region of reporting institution (Northeast [NE], Midwest [MW], South and West); month/year of COVID-19 diagnosis (classified into 4-month intervals); smoking status; obesity; comorbidities (cardiovascular, pulmonary, renal, or diabetes mellitus); Eastern Cooperative Oncology Group (ECOG) performance status (PS); BC subtypes based on hormone receptor (HR) and human epidermal growth factor receptor 2 (HER2) expression (HR+/HER2-, HR+/HER2+, HR-/HER2+, HR-/HER2- [triple negative], missing/unknown); cancer status at time of COVID-19 diagnosis; timing of most recent anti-cancer therapy relative to COVID-19 diagnosis (never or after COVID-19 diagnosis, 0-4 weeks, 1-3 months, >3 months); and modality of anti-cancer therapy received within three months of COVID-19 diagnosis. Cancer status was defined as remission or no evidence of disease (NED) for >5 years, remission or NED for ≤ 5 years, and active disease, with active disease further classified as responding to therapy, stable, or progressing. Anti-cancer modalities were categorized as chemotherapy; cyclin-dependent kinase (CDK) 4/6 inhibitor; anti-HER2 therapy; other targeted therapy (non-CDK 4/6 inhibitor, non-anti-HER2 therapy); endocrine therapy; immunotherapy; and locoregional

therapy (surgery and/or radiation). In the survey, drug classes (modalities) along with a few specific drugs (through checkboxes) were captured. Survey respondents were also encouraged to provide additional details in the free text boxes which were reviewed extensively by the Informatics Core at VUMC, and queries were sent to participating sites to clarify ambiguous reports. CDK 4/6 inhibitor, anti-HER2 therapy and other targeted therapy information was extracted from free text in the registry survey while the others were checkboxes. In addition, baseline severity of COVID-19 at presentation, classified as mild (no hospitalization indicated), moderate (hospitalization indicated), and severe (ICU admission indicated) was collected. Other variables included location of patient residence (urban, suburban, rural) and treatment center characteristics (academic medical center, community practice, tertiary care center). The CCC19 data dictionary is available at https://github.com/covidncancer/CCC19_dictionary. The project approved variables used for the analysis are provided in *supplementary appendix*.

Statistical methods

Covariates, outcome definitions, and statistical analysis plan were pre-specified by the authors and the CCC19 Research Coordinating Center prior to analysis (*supplementary appendix*). Standard descriptive statistics were used to summarize prognostic factors, rates of clinical complications, interventions during hospitalization, and rates of outcomes such as 30-day mortality, hospitalization, oxygen requirement, ICU admission, mechanical ventilation, and overall mortality among racial and ethnic groups. The primary analysis was restricted to females with BC.

Multivariable ordinal logistic regression models for the COVID-19 severity outcome among females with BC included age, race/ethnicity, obesity, ECOG PS, co-morbidities, cancer status, anti-cancer therapy and timing, month/year of COVID-19 diagnosis (classified into 4-month intervals), and U.S census region of reporting institution. These covariates were identified *a priori* as the most clinically relevant for COVID-19 severity and were included in a single model, given a sufficient number of events and corresponding degrees of freedom. Because the ordinal outcome was assessed over a given patients' total follow-up period, the model included an offset for (log) follow-up time. The results are presented as adjusted odds ratio (ORs) with 95% CIs. Model stability was assessed by comparing unadjusted and adjusted models and variance inflation factors. Graphical methods were used to verify the proportional odds assumption (*supplementary appendix- figure I*). We used the e value to quantify sensitivity to unmeasured confounding for the observed OR for race/ethnicity.[33], [34] Multiple

imputation (20 imputed datasets) was used to impute missing and unknown data for all variables included in the analysis, with some exceptions: unknown ECOG performance score and unknown cancer status were not imputed and treated as a separate category in analyses. Imputation was performed on the largest dataset possible (that is, after removing test cases and other manual exclusions, but before applying specific exclusion criteria). Analyses were completed using R v4.0.4 (R Foundation for Statistical Computing, Vienna, Austria), including the rms and EValue extension packages. Descriptive statistics for males with BC and females with metastatic BC are presented separately but multivariable modeling was not attempted due to small sample sizes.

RESULTS

Baseline characteristics and COVID-19 Outcomes in female patients with BC

Of the total 12,034 reports on all cancers submitted to the CCC19 registry at the time of this analysis, 1,383 females with BC met the eligibility criteria and were included (**Figure I**). The median age for the cohort was 61 years (IQR 51-72 years) and median follow-up was 90 (IQR 30-135) days. BC subtypes by biomarker distribution in CCC19 registry included: 52% HR+/HER2-, 14% HR+/HER2+, 8% HR-/HER2+, 11% triple negative, and 14% unknown or missing. BC subtype distribution based on biomarkers in the CCC19 cohort are similar to SEER data which adds broader applicability of these findings.[35] With regards to BC status, 27% were in remission/NED for over 5 years and 32% were in remission/NED for less than 5 years since the initial BC diagnosis and 32% had active cancer (13% had active and responding, 12% had active and stable and 7% had active and progressing cancer). 57% of patients had received some form of anti-cancer therapy within 3 months of COVID-19 diagnosis. The unadjusted total all-cause mortality and hospitalization rate, included in the primary ordinal outcome, for the female cohort was 9% and 37%, respectively. However, the unadjusted rates of COVID-19 outcomes varied by their BC status; females with active and progressing cancer had the highest all-cause mortality (38%) and hospitalization rates (72%) compared to the rest of the group (*supplementary appendix - table I).* Other clinical outcomes for the female cohort included 30-day all-cause mortality (6%), mechanical ventilation (5%) and ICU care (8%). Additional details on patients with BC and COVID-19 by specific characteristics of interest are presented below.

Characteristics of female patients with BC and COVID-19 by Race/Ethnicity

Of the 1383 female patients, 736 (53%) were NHW, 289 (21%) Black, 235 (17%) Hispanic, 45 (3%) AAPI, and 78 (6%) belonged to Other racial/ethnic group. Baseline characteristics of females stratified by race/ethnicity groups are shown in **Table I**. Hispanic and AAPI patients were younger with median ages of 53 (IQR 46-62) and 54 (IQR 43-73) years respectively, compared to 64 years in NHW (IQR 54-76) and 61 years (IQR 52-69) in Black patients. Prevalence of smokers were higher among NHW (35%), Black (33%) and Other (32%) racial/ethnic groups compared to Hispanic (23%) and AAPI (18%) patients. Rates of obesity was higher in Black (54%) and lower in AAPI (29%) compared to NHW (42%) patients. Cardiovascular comorbidity was less common in Hispanic patients (6%), while diabetes mellitus was more prevalent among Black patients (34%) compared to NHW patients (24% and 17% respectively). Compared to NHW, Hispanic patients had higher rates of active cancer (24% responding, 15% stable, and 9% progressing) and had higher rates of receipt of anti-cancer systemic therapy within 3 months of COVID-19 diagnosis (37% chemotherapy, 25% targeted therapy, 39% endocrine therapy). Similarly, AAPI patients also had higher rates of active cancer (7% responding, 22% stable, and 13% progressing) and received anti-cancer systemic therapy within 3 months of COVID-19 diagnosis (24% chemotherapy, 18% targeted therapy, 33% endocrine therapy) compared to NHW patients with active cancer [9% responding, 12% stable, and 6% progressing] who received anti-cancer systemic therapy [16% chemotherapy, 15% targeted therapy, 38% endocrine therapy]). With regards to baseline severity of COVID-19 at presentation, 39% of Black and 38% of AAPI patients presented with moderate or higher severity of COVID-19 infection compared to 27% in both NHW and Hispanic patients. **Table II** summarizes the clinical outcomes, complications, and interventions, stratified by race/ethnicity.

Characteristics of female patients with Metastatic Breast Cancer (MBC) and COVID-19

Female patients with MBC consisted of 17% of the cohort (N=233), with median age 58 years [IQR 50-68]. Racial/Ethnic groups consisted of 46% NHW, 24% Black, 21% Hispanics, 4% AAPI and 4% Other. Most patients with MBC were never smokers (70%) and non-obese (60%). The predominant tumor biology was HR+/HER2- (42%) followed by HR+/HER2+(23%). The most common sites of metastases were bone (58%), lung (28%), and liver (26%). A high percentage (87%) had received anti-cancer treatment within 3 months prior to COVID-19 diagnosis and 32% had active and progressing cancer. The unadjusted total all-cause mortality and hospitalization rate in females with MBC was 19% and 53%

respectively. Further details of baseline characteristics and unadjusted rates of COVID-19 outcomes, complications and interventions are presented in *supplementary appendix – Table IIA and IIB*

BC Treatment Characteristics

758 (55%) out of 1383 female patients with BC received some form of systemic treatment within 3 months prior to COVID-19 diagnosis, and specific drug information was available for 679 (90%) (**Table III**). Of these 679 patients, the most common systemic therapy was endocrine therapy alone (n=336, 49.5%). This was followed by chemotherapy in 163 (24%) patients who received it either as single agent (n=55, 8%) or combination chemotherapy (n=60, 9%) or combined with anti-HER2 therapy (n=48, 7%). 78 (11.5%) patients received anti-HER2 therapy with or without endocrine therapy, and 63 (9%) patients received CDK4/6 inhibitors with or without endocrine therapy.

Prognostic Factors associated with COVID-19 severity

After adjusting for baseline demographic, clinical, and spatiotemporal factors in multivariable analysis model, factors associated with worse outcomes in females with BC included older age (aOR per decade, 1.48 [95% CI, 1.32 – 1.67]); Black (aOR, 1.74 [95% CI, 1.24 - 2.45]), AAPI (aOR, 3.40 [95% CI, 1.70 - 6.79]), and Other (aOR, 2.97 [95% CI, 1.71 - 5.17]) racial/ethnic group; cardiovascular (aOR, 2.26 [95% CI, 1.63 – 3.15]) and pulmonary (aOR, 1.65 [95% CI, 1.20 – 2.29]) comorbidities; diabetes mellitus (aOR, 2.25 [95% CI, 1.66 – 3.04]); worse ECOG PS (ECOG PS 1: aOR, 1.74 [95% CI, 1.22 – 2.48]; ECOG PS ≥2: aOR, 7.78 [95% CI, 4.83 – 12.5]); and active and progressing cancer status (aOR, 12.5 [95% CI, 6.89 – 22.6]). Association between Hispanic ethnicity, obesity, preexisting renal disease, anti-cancer treatment modalities including all forms of systemic therapy and loco-regional therapy, month/year and geographic region of COVID-19 diagnosis and COVID-19 severity did not reach statistical significance **(Table IV).** The e value for the COVID-19 severity OR and CI for each racial group are shown in *supplementary appendix - Table III.* This value demonstrates the impact of unknown _*residual*_ confounding above that adjusted for by including adjustment variables in the multivariable model. For example, an unmeasured confounder would need to be associated with both race and mortality with a odds ratio of at least 1.97 to fully attenuate the observed association for Black females and the odds ratio would need to be at least 1.47 for the null-hypothesized value (1.0) to be included in the CI. Similarly, E value estimates are noted for AAPI and Other groups. The

unmeasured confounding for other races based on the e value is larger than most documented associations in the CCC19 cohort. [3]

Male patients with BC and COVID-19

Male patients with BC were evaluated separately as part of exploratory analysis. The median age for male BC cohort (N=25) was 67 years [IQR 60-75]. Racial/ethnic composition consisted of NHW (52%) followed by Black (32%) males. Most males with BC were non-smokers (72%) and diabetes mellitus was the predominant comorbidity (44%). The hospitalization rate was 60% and all-cause mortality was 20%. Additional clinical characteristics, complications, interventions, and unadjusted outcomes among males with BC in the CCC19 registry are provided in *supplementary appendix – table IV*.

DISCUSSION

In this large, multi-institutional and racially diverse cohort of females with BC and COVID-19 from CCC19 registry, we assessed the clinical impact of COVID-19. The all-cause mortality from COVID-19 was 9% and hospitalization rate was 37%, which is numerically lower than in the entire CCC19 cohort at 14% and 58%, and other previously reported studies of COVID-19 in patients with cancer.[3]–[8], [36] These differences in outcomes could indicate differences in the immunocompromised status of patients due to intensity of therapy regimens, complex comorbidities, or concomitant medications, which may affect outcomes. Females with BC, however, form a heterogenous group, and the rates of outcomes varied widely with their disease status; patients with active and progressing cancer had the highest total all-cause mortality (38%) and hospitalization rates (72%).

We observed older age, pre-existing cardiovascular and pulmonary comorbidities, diabetes mellitus, worse ECOG PS, and active and progressing cancer status were associated with adverse COVID-19 outcomes in females with BC. Prior studies have reported similar factors to be associated with adverse COVID-19 outcomes in patients with all cancer types. The majority of these studies have reported older age to be an important prognostic factor for adverse outcomes from COVID-19, including mortality, which is consistent with data presented here.[3], [9], [10], [36], [37] Non-cancer comorbidities, contributing to poor COVID-19 outcomes, as noted in our study, have also been a consistent finding in patients with and without a cancer diagnosis.[3], [9], [10], [37], [38] Similarly, poor ECOG PS in cancer patients has been noted to be an

important factor associated with worse COVID-19 severity, including our study.[3], [8], [10] While obesity was reported in some cancer studies to have a negative impact on COVID-19 [3], [37], our study did not identify this association. In this cohort of females with BC, all forms of anti-cancer therapy were thoroughly evaluated and none of the systemic therapies including chemotherapy; endocrine therapy; and targeted therapy (anti-HER2, CDK4/6 inhibitors, other non-HER2 or non-CDK4/6 inhibitors); or loco-regional therapy (surgery and radiation) received within 3 months of COVID-19 diagnosis was significantly associated with adverse COVID-19 outcomes. Our finding suggests that systemic therapy for females with BC may not add excess COVID-19 risk. Multiple large cohort studies and meta-analysis of patients with cancer diagnosed with COVID-19 similarly did not identify active anti-cancer therapy, specifically chemotherapy, as a factor associated with adverse COVID-19 outcomes, which is consistent with our results.[4], [5], [8], [36], [39], [40] However, in contrast, some studies of patients with other cancers have shown a negative impact of chemotherapy[3], [9], [10], [37] and immunotherapy use [37]. These findings have important clinical implications while counselling and providing patient care during the pandemic.

We also report important findings related to the impact of racial/ethnic inequities in females with BC and COVID-19, which adds to the growing body of literature on COVID-19 related racial/ethnic disparities. In our study, Black females with BC had significantly worse COVID-19 outcomes compared to NHW females. Multiple studies have similarly reported Black patients in US with and without cancer diagnosis having significantly worse COVID-19 outcomes [3], [6], [11] however, our study is the first to show such racial/ethnic disparities in COVID-19 outcomes in females with BC. There was no statistically significant association of worse outcomes for Hispanic females compared to NHW females. This is different in comparison to our overall CCC19 cohort[3], and may be explained by younger age and lower rates of comorbid conditions in Hispanic females compared to NHW females. We also found females belonging to AAPI, and Other racial/ethnic group to have worse COVID-19 outcomes. Notably, females belonging to Black, AAPI and Other racial/ethnic groups presented with higher rates of moderate or severe symptoms of COVID-19 at baseline, which likely contributed to their worse outcomes. This in turn is possibly related to barriers to health care access, and other socio-cultural reasons for delay in seeking early medical care. Future studies including social determinants of health, access to health care, and lifestyle behaviors, among others, are warranted to identify barriers contributing to worse clinical presentation in racial/ethnic minority groups, and eventually impacting future health policies.

In summary, this is one of the largest cohort studies to evaluate the clinical impact of COVID-19 on females with BC. Strengths of our study include standardized data collection on the most common cancer in females in the US and large sample size to evaluate the effect of major clinical and demographic factors. The study had representative population by race and ethnicity from geographically diverse areas and variable time/period of COVID-19 diagnosis. In addition, our study has detailed manually collected information on both cancer status and treatment modalities which contrasts with other studies that have utilized either of these variables as surrogate. Limitations of this study include the retrospective nature of data and inherent potential for confounding because of its observational nature. It's possible that ascertainment bias could have led to some of the high values observed in specific groups such as females with MBC and those with active and progressing cancer. Additional information on drivers for inequity such as socio-economic status, occupation, income, residence, education, and insurance status may have provided added insights on the root causes for disparities; however, unavailability of these factors does not nullify our current findings of existing racial disparities in COVID-19 outcomes in females with BC. Vaccination status was not part of this study as vaccines were not available during the predominant time frame for this cohort. Data presented here including the risk of hospitalization and death applies to the specific COVID-19 variants prevalent during the study period. Despite these limitations, the study reports important sociodemographic and clinical factors that aid in identifying females with BC who are at increased risk for severe COVID-19 outcomes.

Our study addresses an important knowledge gap in patients with BC diagnosed with COVID-19 using the CCC19 registry. In addition to clinical and demographic factors associated with adverse COVID-19 outcomes, racial/ethnic disparities reported here significantly contribute to the growing literature. At this stage, it is irrefutable that one of the principal far-reaching messages the pandemic has conveyed is that any such major stressors on the health care system increases risk of detrimental outcomes to the most vulnerable patient population, including the underrepresented and the underserved. These are important considerations for future resource allocation strategies and policy interventions. We also report an important finding that cancers that are active and progressing are associated with severe COVID-19 outcomes. During the ongoing pandemic, this has significant implications for shared decision-making between patients and physicians.

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ETHICS APPROVAL:

This study was exempt from institutional review board (IRB) review (VUMC IRB#200467) and was approved by IRBs at participating sites per institutional policy.

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Table I: Baseline Characteristics by Race/Ethnicity

	NHW (n = 736, 53%)	Black (n = 289, 21%)	Hispanic (n = 235, 17%)	AAPI (n = 45, 3%)	Others (n=78, 6%)	All (n = 1383, 100%)
Median Age, years[a] [IQR]	64 (54-76)	61 (52-69)	53 (46-62)	54 (43-73)	62 (53-71)	61 (51-72)
Median follow-up, days [IQR]	90 (30-135)	90 (30-180)	90 (30-135)	42 (21-90)	70 (30-180)	90 (30-135)
Smoking status						
Never	460 (62%)	186 (64%)	180 (77%)	35 (78%)	50 (64%)	911 (66%)
Current or Former	261 (35%)	95 (33%)	53 (23%)	8 (18%)	25 (32%)	442 (32%)
Missing/unknown	15 (2%)	8 (3%)	2 (1%)	2 (4%)	3(4%)	30 (2%)
Obesity						
No	421 (57%)	133 (46%)	116 (49%)	32 (71%)	45 (58%)	747 (54%)
Yes	308 (42%)	156 (54%)	116 (49%)	13 (29%)	33 (42%)	626 (45%)
Missing/unknown	7 (1%)	0 (0%)	3 (1%)	0 (0%)	0 (0%)	10 (1%)
Comorbidities[b]						
Cardiovascular	179 (24%)	60 (21%)	14 (6%)	7 (16%)	11 (14%)	271 (20%)
Pulmonary	125 (17%)	65 (22%)	33 (14%)	<5 (<11%)	7 (9%)	234 (17%)
Renal Disease	66 (9%)	31 (11%)	13 (6%)	<5 (<11%)	<5 (<6%)	115 (8%)
Diabetes mellitus	127 (17%)	98 (34%)	51 (22%)	10 (22%)	20 (26%)	306 (22%)
Missing/unknown	9 (1%)	1 (<1%)	5 (2%)	0 (0%)	0 (0%)	15 (1%)
ECOG performance status						
0	314 (43%)	130 (45%)	123 (52%)	18 (40%)	32 (41%)	617 (45%)
1	135 (18%)	72 (25%)	48 (20%)	10 (22%)	16 (21%)	281 (20%)
2+	69 (9%)	33 (11%)	15 (6%)	5 (11%)	5 (6%)	127 (9%)
Unknown	218 (30%)	53 (18%)	49 (21%)	12 (27%)	25 (32%)	357 (26%)
Missing	0 (0%)	1 (<1%)	0 (0%)	0 (0%)	0 (0%)	1 (<1%)
Region						
Northeast	247 (34%)	101 (35%)	106 (45%)	12 (27%)	26 (33%)	492 (36%)
Midwest	239 (32%)	110 (38%)	23 (10%)	8 (18%)	12 (15%)	392 (28%)
South	116 (16%)	58 (20%)	27 (11%)	X*	14 (18%)	218 (16%)
West	128 (17%)	16 (6%)	77 (33%)	22 (49%)	24 (31%)	267 (19%)
Undesignated	6 (1%)	4 (1%)	2 (1%)	3 (7%)*	2 (3%)	14 (1%)
Month/Year of COVID-19 diagnosis						
Jan-Apr 2020	140 (19%)	74 (26%)	41 (17%)	8 (18%)	20 (26%)	283 (20%)
May-Aug 2020	279 (38%)	141 (49%)	101 (43%)	24 (53%)	30 (38%)	575 (42%)
Sept-Dec 2020	197 (27%)	42 (15%)	50 (21%)	5 (11%)	16 (21%)	310 (22%)
Jan-Jun 2021	118 (16%)	32 (11%)	41 (17%)	7 (16%)	12 (15%)	210 (15%)
Missing/unknown	2 (<1%)	0 (0%)	2 (1%)	1 (2%)	0 (0%)	5 (<1%)
Area of patient residence						
Urban	193 (26%)	136 (47%)	124 (53%)	13 (29%)	30 (38%)	496 (36%)
Suburban	315 (43%)	77 (27%)	65 (28%)	17 (38%)	31 (40%)	505 (37%)
Rural	81 (11%)	7 (2%)	9 (4%)	X*	0 (0%)	98 (7%)

Missing/unknown	147 (20%)	69 (24%)	37 (16%)	15 (33%)*	17 (22%)	284 (21%)
Treatment center characteristics						
Academic Medical Center	123 (17%)	102 (35%)	43 (18%)	7 (16%)	11 (14%)	286 (21%)
Community Practice	238 (32%)	51 (18%)	44 (19%)	X*	23 (29%)	359 (26%)
Tertiary Care Center	375 (51%)	136 (47%)	147 (63%)	35 (78%)	44 (56%)	737 (53%)
Missing/unknown	0 (0%)	0 (0%)	1 (<1%)	3 (7%)*	0 (0%)	1 (<1%)
Receptor status						
HR+/HER2-	419 (57%)	135 (47%)	102 (43%)	22 (49%)	43 (55%)	721 (52%)
HR+/HER2+	102 (14%)	35 (12%)	43 (18%)	7 (16%)	9 (12%)	196 (14%)
HR-/HER2+	46 (6%)	28 (10%)	32 (14%)	X*	X*	111 (8%)
Triple Negative	57 (8%)	54 (19%)	35 (15%)	5 (11%)	7 (9%)	158 (11%)
Missing/unknown	112 (15%)	37 (13%)	23 (10%)	11 (24%)*	19 (24%)*	197 (14%)
Cancer status						
Remission/NED, >5 yrs	247 (34%)	76 (26%)	23 (10%)	9 (20%)	20 (26%)	375 (27%)
Remission/NED, <5 yrs	234 (32%)	100 (35%)	77 (33%)	11 (24%)	26 (33%)	448 (32%)
Active and responding	68 (9%)	35 (12%)	56 (24%)	X*	11 (14%)	173 (13%)
Active and stable	91 (12%)	28 (10%)	35 (15%)	10 (22%)	5 (6%)	169 (12%)
Active and progressing	41 (6%)	27 (9%)	20 (9%)	6 (13%)	X*	97 (7%)
Unknown	48 (7%)	19 (7%)	22 (9%)	6 (13%)*	15 (19%)*	104 (8%)
Missing	7 (1%)	4 (1%)	2 (1%)	3 (7%)	1 (1%)	17 (1%)
Timing of anti-cancer therapy						
Never/After COVID-19	24 (3%)	10 (3%)	7 (3%)	X*	7 (9%)	50 (4%)
0-4 weeks	364 (49%)	135 (47%)	158 (67%)	25 (56%)	39 (50%)	721 (52%)
1-3 months	26 (4%)	20 (7%)	19 (8%)	0 (0%)	X*	69 (5%)
>3 months	303 (41%)	118 (41%)	45 (19%)	18 (40%)	24 (31%)	508 (37%)
Missing/unknown	19 (3%)	6 (2%)	6 (3%)	2 (4%)*	8 (10%)*	35 (3%)
Modality of active anti-cancer therapy[b,c]						
None	333 (45%)	127 (44%)	53 (23%)	20 (44%)	30 (38%)	563 (41%)
Chemotherapy	117 (16%)	68 (24%)	88 (37%)	11 (24%)	14 (18%)	298 (22%)
Targeted Therapy	112 (15%)	38 (13%)	59 (25%)	8 (18%)	11 (14%)	228 (16%)
Anti-HER2 therapy	60 (8%)	17 (6%)	36 (15%)	<5 (<11%)	<5 (<6%)	123 (9%)
CDK4/6 inhibitor	33 (4%)	12 (4%)	14 (6%)	<5 (<11%)	<5 (<6%)	65 (5%)
Other[d]	14 (2%)	5 (2%)	<5 (<2%)	<5 (<11%)	0 (0%)	24 (2%)
Endocrine Therapy	283 (38%)	86 (30%)	91 (39%)	15 (33%)	26 (33%)	501 (36%)
Immunotherapy	12 (2%)	8 (3%)	<5 (<2%)	<5 (<11%)	<5 (<6%)	28 (2%)
Local (Surgery/Radiation)	80 (11%)	37 (13%)	41 (17%)	<5 (<11%)	9 (12%)	172 (12%)
Other	13 (2%)	3 (1%)	2 (1%)	0 (0%)	0 (0%)	18 (1%)
Missing/unknown	12 (2%)	7 (2%)	5 (2%)	0 (0%)	5 (6%)	29 (2%)
Severity of COVID-19						
Mild	535 (73%)	177 (61%)	173 (74%)	28 (62%)	50 (64%)	963 (70%)
Moderate	174 (24%)	97 (34%)	56 (24%)	14 (31%)	21 (27%)	362 (26%)
Severe	25 (3%)	15 (5%)	6 (3%)	X*	7 (9%)	56 (4%)
Missing/unknown	2 (<1%)	0 (0%)	0 (0%)	3 (7%)*	0 (0%)	2 (<1%)

***Cells combined to mask N<5 according to CCC19 low count policy**
[a]Age was truncated at 90
[b]Percentages could sum to >100% because categories are not mutually exclusive
[c]Within 3 months of COVID-19 diagnosis.
[d]Therapies other than Anti-Her2 therapy or CDK4/6 inhibitor
Variable categories with one to five cases are masked by replacing with N < 5 according to CCC19 policy

Table II: Outcomes, Clinical Complications, and COVID-19 Interventions

	NHW n[a] (%)	Black n[a] (%)	Hispanic n[a] (%)	AAPI n[a] (%)	Other n[a] (%)	All n[a] (%)
Outcomes						
Total all-cause mortality[b]	60 (8)	38 (13)	12 (5)	<5(<11)	9 (12)	123 (9)
30-day all-cause mortality[c]	40 (5)	29 (10)	8 (3)	<5 (<11)	8 (10)	89 (6)
Received mechanical ventilation[b]	24 (3)	26 (9)	11 (5)	<5 (<11)	<5 (<6)	69 (5)
Admitted to an intensive care unit[b]	45 (6)	31 (11)	18 (8)	7 (16)	10 (13)	111 (8)
Admitted to the hospital[b]	245 (33)	137 (47)	77 (33)	20 (44)	33 (42)	512 (37)
Clinical complications						
Any cardiovascular complication[d]	82 (11)	50 (17)	30 (13)	6 (13)	18 (23)	186 (14)
Any pulmonary complication[e]	170 (23)	88 (31)	43 (18)	12 (27)	23 (30)	336 (24)
Any gastrointestinal complication[f]	12 (2)	7 (2)	<5 (<2)	<5 (<11)	<5 (<7)	26 (2)
Acute kidney injury	41 (6)	46 (16)	11 (5)	5 (11)	10 (13)	113 (8)
Multisystem organ failure	10 (1)	12 (4)	<5 (<2)	<5 (<11)	<5 (<7)	29 (2)
Superimposed infection	62 (9)	42 (15)	14 (6)	7 (16)	<5 (<7)	129 (10)
Sepsis	43 (6)	24 (8)	15 (6)	7 (16)	12 (16)	101 (7)
Any bleeding	15 (2)	7 (2)	<5 (<2)	<5 (<11)	<5 (<7)	29 (2)
Interventions						
Remdesivir	68 (10)	20 (7)	15 (7)	8 (18)	5 (7)	116 (9)
Hydroxychloroquine	60 (9)	41 (15)	14 (6)	<5 (<11)	11 (15)	129 (10)
Systemic Corticosteroids	107 (15)	50 (18)	31 (14)	8 (18)	13 (18)	209 (16)
Other	112 (16)	53 (19)	36 (16)	11 (25)	12 (17)	224 (17)
Supplemental oxygen	173 (24)	87 (31)	43 (19)	14 (31)	24 (31)	341 (25)

Variable categories with one to five cases are masked by replacing with N < 5 according to CCC19 policy

[a] N based on number of patients with non-missing data.

[b] Included in primary outcome

[c] Secondary outcome

[d] Cardiovascular complication includes hypotension, myocardial infarction, other cardiac ischemia, atrial fibrillation, ventricular fibrillation, other cardiac arrhythmia, cardiomyopathy, congestive heart failure, pulmonary embolism (PE), deep vein thrombosis (DVT), stroke, thrombosis NOS complication.

[e] Pulmonary complication includes respiratory failure, pneumonitis, pneumonia, acute respiratory distress syndrome (ARDS), PE, pleural effusion, empyema.

[f] Gastrointestinal complication includes acute hepatic injury, ascites, bowel obstruction, bowel perforation, ileus, peritonitis

Table III: Systemic Treatments Received within 3 months prior to COVID-19 Diagnosis

	N (%)
Total	**679 (100%)**
Endocrine therapy alone	336 (49.5)
CDK4/6 inhibitor +/- Endocrine therapy	63 (9)
Other targeted therapy +/- Endocrine therapy	10 (1.5)
Anti-HER2 therapy +/- Endocrine therapy	78 (11.5)
Anti-HER2 therapy + Chemotherapy	48 (7)
Single agent chemotherapy +/- Endocrine therapy	55 (8)
Combination chemotherapy +/- Endocrine therapy	60 (9)
Immunotherapy +/- Chemotherapy	19 (3)
Other combination therapies	10 (1.5)

Table IV: Adjusted Associations of Baseline Characteristics with COVID-19 Severity Outcome.

	COVID-19 severity
	OR (95% CI)
Age (per decade)	**1.48 (1.32- 1.67)**
Race (Ref: Non-Hispanic White) [a]	
Non-Hispanic Black	**1.74 (1.24- 2.45)**
Hispanic	1.38 (0.93- 2.05)
Non-Hispanic AAPI	**3.40 (1.70- 6.79)**
Other	**2.97 (1.71- 5.17)**
Obesity (Ref: No)	1.20 (0.92- 1.57)
Cardiovascular Comorbidity (Ref: No)	**2.26 (1.63- 3.15)**
Pulmonary Comorbidity (Ref: No)	**1.65 (1.20- 2.29)**
Renal Disease (Ref: No)	1.34 (0.86- 2.07)
Diabetes Mellitus (Ref: No)	**2.25 (1.66- 3.04)**
ECOG Performance Status (Ref: 0)	
1	**1.74 (1.22- 2.48)**
2+	**7.78 (4.83-12.5)**
Unknown	**2.26 (1.61- 3.19)**
Cancer Status (Ref: Remission/NED, >5 years)	
Remission or NED, <5 years	0.91 (0.63- 1.33)
Active and responding	1.07 (0.63- 1.83)
Active and stable	1.37 (0.82- 2.28)
Active and progressing	**12.5 (6.89-22.6)**
Unknown	1.79 (0.96- 3.34)
Chemotherapy (Ref: No)	1.37 (0.91- 2.06)
Anti-HER2 Therapy (Ref: No)	1.13 (0.67- 1.92)
CDK 4/6 inhibitor (Ref: No)	1.21 (0.60- 2.42)
Other Targeted Therapies [b] **(Ref: No)**	1.78 (0.69- 4.59)
Endocrine Therapy (Ref: No)	1.00 (0.73- 1.37)
Locoregional Therapy (Ref: No)	1.36 (0.88- 2.10)
Never received cancer treatment (Ref: >3 month)	0.65 (0.28- 1.49)
Month/Year of COVID-19 Diagnosis (Ref: Jan-Apr 2020)	
May-Aug 2020	0.57 (0.41- 0.81)
Sept-Dec 2020	0.45 (0.30- 0.68)
Jan-Jun 2021	0.57 (0.36- 0.89)
Region (Ref: Northeast)	

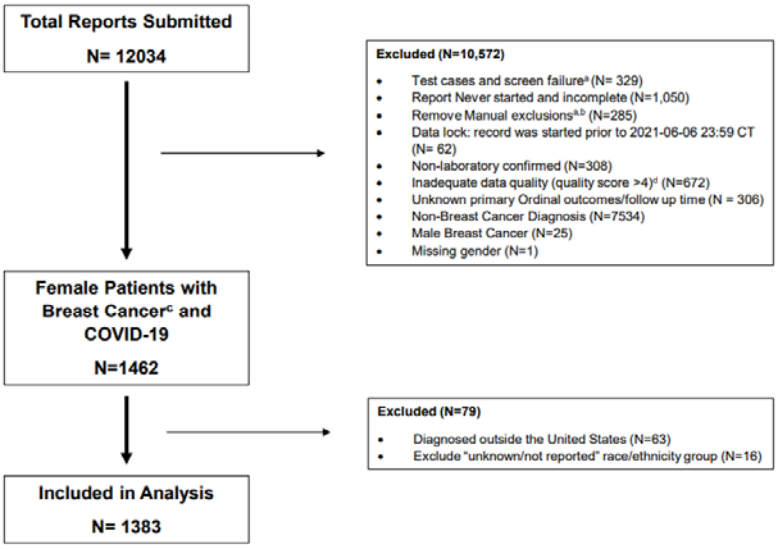
Midwest	0.76 (0.54- 1.05)
South	0.76 (0.51- 1.13)
West	0.43 (0.29- 0.65)

[a] Odds ratios greater than 1 indicate higher odds of composite outcome. The P value for evaluating the null hypothesis of equality in odds ratios across race (4 degrees of freedom) was <0.001.

[b] Therapies other than CDK4/6 inhibitor or Anti- HER2 therapy

All variance inflation factors are <1.8 for the model

Figure I: Consort Flow Diagram



[a] Some Non-melanoma skin cancer, in situ cancers, premalignant conditions are excluded in this step.

[b] Manual exclusions = Duplicate records; In situ solid malignancy; Precursor hematologic condition; Benign hematologic condition; False positive SARS-CoV-2 test; Non-melanoma skin cancer; Non-invasive cancer; Low-quality score; Non-CCC29 site.

[c] Breast cancer defined as active or previous history of single primary breast cancer. Multiple primary cancers or bilateral breast cancer with exception of DCIS in the contralateral breast cancer were excluded.

[d] Data quality problems were classified as minor (1 point), moderate (3 points), and major (5 points) and reports with quality scores > 4 using previously defined metrics were excluded

Supplementary Appendix

TABLE OF CONTENTS

APPENDIX A: CCC-19 Quality Scores

The CCC-19 uses a quality scoring system to determine the suitability of records for inclusion in analyses. A score greater than 5 was considered insufficient for inclusion in the analysis presented. Scores are tabulated as follows:

Minor problems (+1 points per problem)
ADT missing/unknown (prostate cancers only)
Biomarkers missing/unknown (breast cancers only)
ICU admission missing/unknown
Hospitalization missing/unknown
Mechanical ventilation missing/unknown
O2 ever needed missing/unknown
Days to death missing/unknown
Cancer status unknown
ECOG PS unknown
Missing cancer drug names for patients on systemic anti-cancer treatment
Missing or unknown categorical lab values if labs were drawn

Moderate problems (+3 points per problem)
Cancer status missing
ECOG PS missing
Death status missing/unknown
Baseline COVID-19 severity missing/unknown
Should have 30-day follow-up but doesn't

Major problems (+5 points per problem)
High levels of missingness
High levels of unknowns

APPENDIX B: Breast Cancer Disparities Statistical Analysis Plan:

Approved Project Title: **Racial and Ethnic Disparities among Patients with Breast Cancer and COVID-19 in CCC19 Cohort**

Project Team Leads: Gayathri Nagaraj, Melissa Accordino, Maryam Lustberg, Dimpy Shah

Name of the investigator completing this survey: Gayathri Nagaraj and Melissa Accordino

Proposed milestone deadline for this manuscript:

- Abstract submission for ASCO 2021, deadline February 17 completed.
- ASCO abstract accepted for oral presentation. Deadlines for prelim slide upload May 7, and final deadline for uploading slides May 14.
- Manuscript preparation simultaneously, deadline and journal TBD

Do you have local statistical support: No

Name and emails of (at most) 2 additional project team members who would like to be part of the analysis team for the project:

Melissa Accordino, Email: mkg2134@cumc.columbia.edu

Maryam Lustberg, Email: Maryam.Lustberg@osumc.edu

Dimpy Shah, Email: shahdp@uthscsa.edu

Initial draft of the Statistical Analysis Plan (SAP), following STROBE guidelines, for our review and input. Please complete sections 1 and 3-11 (and 12 if you have local statistical support)

1 (a) Manuscript Title: **Racial and Ethnic Disparities among Patients with Breast Cancer and COVID-19 in CCC19 Cohort**

1 (b) Provide in the abstract an informative and balanced summary of what was done and what will be found.

Racial and Ethnic minority subgroups are at a disproportionately increased risk of contracting COVID-19 or experiencing severe illness regardless of age. Racial and Ethnic disparities also affect breast cancer incidence and mortality. The impact of COVID-19 on patients with breast cancer is largely unknown but is currently under investigation. Outcomes of COVID-19 specifically in racial and ethnic minority patients with active or prior history of breast cancer is currently unknown.

3. Objectives

State specific objectives, including any prespecified hypotheses:

The overarching goal of this study is to evaluate the racial and ethnic disparities related to COVID-19 outcomes, in patients with active or previous history of breast cancer. To evaluate this, the following specific aims are proposed:

- **Specific Aim 1: To compare the distribution of major clinical, sociodemographic, and breast cancer risk factors among racial and ethnic subgroups of women with active or previous history of single primary invasive breast cancer diagnosed with COVID-19.**
  We *hypothesize* that racial and ethnic minority women with breast cancer are more likely to have active comorbid conditions, such as diabetes mellitus, obesity, smoking history, and a baseline lower performance status compared to non-Hispanic white (NHW) women with active or previous history of breast cancer diagnosed with COVID-19. Other variables of interest are age, month/year of COVID-19 diagnosis, area of patient residence, geographic region, insurance type, treatment center characteristics, receipt of anti-COVID-19 treatment along with tumor characteristics including breast cancer biologic subtype, cancer status, treatment intent, timing of anti-cancer treatment and modality of anti-cancer treatment.

- **Specific Aim 2: To compare COVID-19 clinical outcomes on a five-level ordinal scale based on patient's most severe reported outcomes: no complications (uncomplicated); hospital admission, intensive care unit (ICU) admission, mechanical ventilation; or death from any cause in racial and ethnic minority subgroups of women with previous or active history of breast cancer compared to NHW adjusted for baseline characteristics. We also plan to evaluate the death within 30 days of COVID-19 diagnosis among racial and ethnic subgroups of women with previous or active history of breast cancer compared to NHW adjusted for baseline characteristics.**
  We *hypothesize* that there will be higher rates of severe COVID-19 related outcomes in the racial and ethnic minority subgroups compared to non-Hispanic white (NHW) patients with active or previous history of breast cancer.

- **Exploratory aims:**

  1. To evaluate the frequency of hospitalization, supplemental oxygen use, ICU admission and use of mechanical ventilation in the various racial ethnic groups**.**
  2. To describe the distribution of major clinical, sociodemographic, breast cancer risk factors and outcomes in men with active or previous history of breast cancer diagnosed with COVID-19.
  3. Assess the rate of major clinical complications such as cardiovascular, pulmonary, gastrointestinal, superimposed infection, vascular thrombosis and others among various racial and ethnic groups of women with active or previous history of breast cancer.

4. Study Design

Study Design:

Present key elements of study design early in the paper

This is a retrospective cohort study using de-identified data from the COVID-19 and Cancer Consortium (CCC19) database which is a centralized multi-institution registry of patients with current or past history of cancer diagnosed with COVID-19. Study data are collected and managed using REDCap software hosted at Vanderbilt University Medical Center.

5. Setting

Setting

Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.

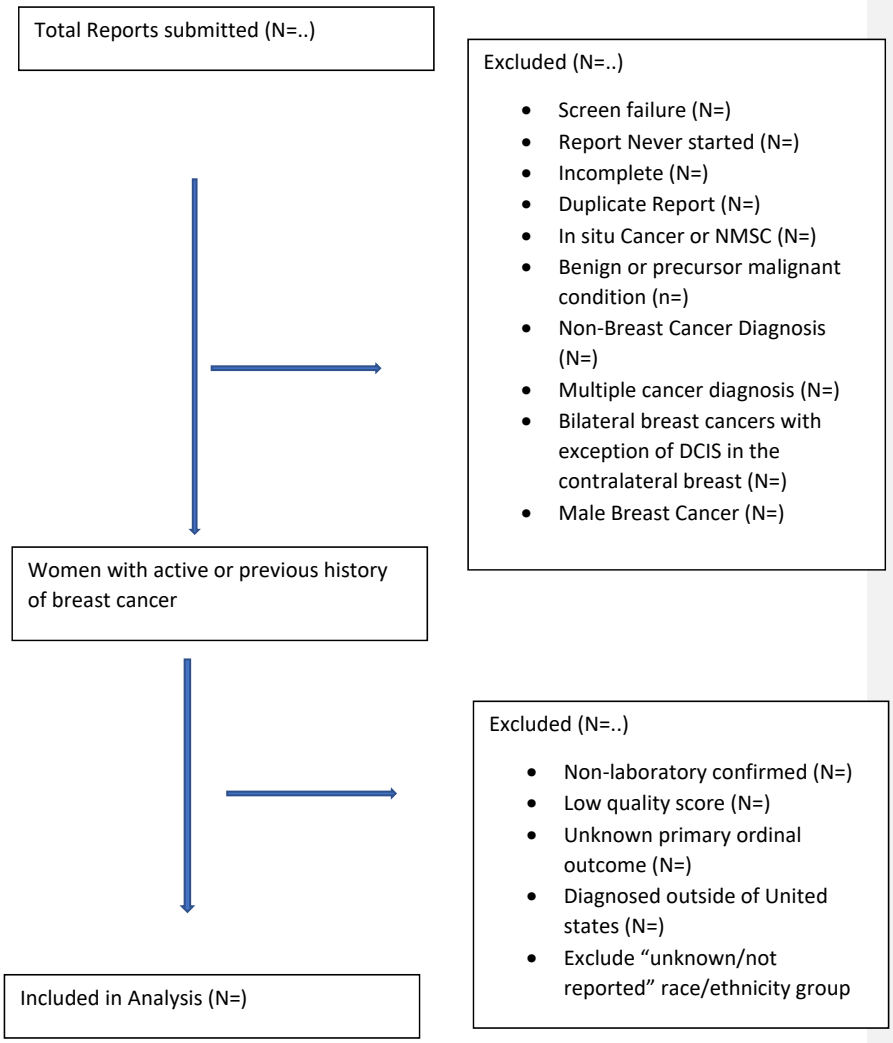
The CCC19 international registry consists of de-identified data on adult patients (18 years and older) with a current or past history of hematologic malignancy or invasive solid tumor who either have laboratory-confirmed SARS-CoV-2 infection or presumptive diagnosis of COVID-19. The CCC19 registry includes patients with either active cancer or a history of cancer and contains variables related to patient demographics, cancer history, and COVID-19 clinical course including receipt of COVID-19 related therapeutics along with follow-up data. The member institutions of the consortium report data through the online REDCap data collection survey developed by CCC19. Data collection period is ongoing, for the purpose of this analysis, the data collected from March 17, 2020 to February 9, 2021 will be used.

6. Participants

(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up:

Patients with active or previous history of invasive breast cancer with evaluable self-reported race/ethnicity data, and with laboratory confirmed COVID-19 will be our study population. While the primary analysis will be restricted to women with active or previous history of breast cancer and descriptive data on men with active or previous history of breast cancer will be provided separately as part of the exploratory analysis given the small numbers. We will restrict our analysis to patients diagnosed in the United States of America since the racial and ethnic disparities of interest have been previously described in United States. We will also exclude patients who have multiple malignancies including a history of bilateral breast cancer with the exception of contralateral DCIS only. Further, patients who are not evaluable for the primary ordinal outcome or with a data quality score >4 will be excluded. For this analysis, the unknown/Not reported category of race and ethnicity will be excluded.

CONSORT flow diagram



(b) For matched studies, give matching criteria and number of exposed and unexposed:

Not applicable as the CCC19 registry does not carry data for cancer patients who are not exposed to Covid-19.

7. Variables (Clearly define all variables)

Outcomes:

- Primary: COVID-19 severity outcome defined on a five-level ordinal scale based on patient's most severe reported outcomes: No complications (uncomplicated); hospital admission; intensive care unit admission, mechanical ventilation; or death from any cause.
- Secondary: 30-day all-cause mortality
- Exploratory/Descriptive:
    - Rates of hospitalization; oxygen requirements; ICU admission; mechanical ventilation.
    - Major clinical complications (cardiovascular, pulmonary, gastrointestinal, AKI, MOF, superimposed infection, sepsis, any bleeding, DIC, Thrombosis).
    - Descriptive statistics for men with breast cancer diagnosed with COVID-19.

Exposures

Predictors

1) Self-reported race
2) Self-reported ethnicity

Potential confounders

Higher priority

1) Age in years
2) Obesity (obese, not obese)
3) Co-morbidities (pulmonary, cardiovascular, renal, diabetes mellitus)
4) ECOG PS (0, 1, ≥2, unknown)
5) Receptor status (Hormone receptor positive, HER2 positive, dual positive, Triple negative)
6) Cancer status (remission < 5 years, remission > 5 years, active stable, active responding, active progressing, unknown)
7) Timing of anti-cancer treatment (never treated, 0-4 weeks, 1-3 months, >3 months)
8) Modality of recent anti-cancer treatment (none, cytotoxic chemotherapy, targeted therapy, endocrine therapy, immunotherapy, locoregional therapy, other)
9) Period of COVID-19 diagnosis (Jan-April 2020, May-August 2020, Sep-Nov 2020, Dec 2020-Feb 2021)

Lower priority

10) Smoking (ever, never)
11) US region of patient residence (NE, MW, South, West)
12) Area of patient residence (urban, suburban, rural)
13) Insurance status (Not insured, private insurance, Medicaid/Medicare, other government, missing/unknown)
14) Treatment center characteristics academic (university, tertiary and NCI designated comprehensive cancer centers), community (practice and hospital), other.

Effect modifiers

None

Diagnostic criteria (if applicable)

8. Data Sources / Measurement

For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.

9. Bias

Describe any efforts to address potential sources of bias

Multivariable regression models will be used to adjust for known confounding variables.

10. Study size

Explain how the study size was arrived at

Study size is based on the number of breast cancer cases reported in the registry at the time of Analysis. Breast cancer is the single largest solid tumor cohort within the CCC19 registry accounting for roughly 21% of cases. The numbers are expected to rise given the steep accrual rate.

11. Quantitative variables

Explain how quantitative variables will be handled in the analyses. If applicable, describe which groupings will be chosen and why

12. Statistical methods

(a) Describe all statistical methods, including those to be used to control for confounding

Primary analysis among women:

Standard descriptive statistics will summarize major clinical, demographic, and breast cancer prognostic factors; clinical complications during hospitalization; and rates of 30-day mortality, hospitalization, oxygen requirement, ICU admission, and mechanical ventilation among racial and ethnic subgroups. Multivariable ordinal and binary logistic regression models will estimate differences in adjusted odds of COVID-19 severity and 30-day mortality, respectively, between racial and ethnic subgroups. Because the ordinal outcome is assessed over patient's total follow-up period, the model will include an offset for (log) follow-up time. Adjustment covariates will be selected first from the "higher priority" confounders listed above, followed by those listed as "lower priority." Coefficients and standard errors from models with different levels of adjustment, variance inflation factors, and clinical judgement will be used to assess model stability.

Descriptive analysis among men:

We will calculate standard descriptive statistics for major clinical, demographic, and breast cancer prognostic factors and clinical complications during hospitalization; rates of 30-day mortality, hospitalization, oxygen requirement, ICU admission, and mechanical ventilation among men with active or previous history of breast cancer.

(b) Describe any methods that will be used to examine subgroups and interactions

None included.

(c) Explain how missing data will be addressed

Multiple imputation will be used to impute missing and unknown data for all variables included in the analysis, with some exceptions: unknown ECOG performance score and unknown cancer status will not be imputed and treated as a separate category in analyses. Imputation will be performed on the largest dataset possible (that is, after removing test cases and other manual exclusions, but before applying specific exclusion criteria). At least 10 imputed datasets will be used.

(d) If applicable, explain how loss to follow-up will be addressed

All observed outcomes will be used with models adjusted for duration of follow-up.

(e) Describe any sensitivity analyses

None.

APPENDIX C: CCC19 Approved Project Variables

Primary Outcome (Table III)

Outcome description	Outcome variable name	Outcome values
Custom ordinal outcome with death at any time	*der_ordinal_v1a*	0 = not hospitalized; 1 = hospitalized; 2 = ICU; 3 = mechanical ventilation; 4 = death at any time
Follow-up in days, with some estimation for intervals	*der_days_fu*	Integer (days)

Secondary Outcome (Table II)

Outcome description	Outcome variable name	Outcome values	Additional Details
Derived dead/alive variable	*der_deadbinary*	0 = No; 1 = Yes; 99 = Unknown	
Derived variable indicating whether patient has died within 30 days of COVID-19 diagnosis (default = No)	der_dead30	0 = No; 1 = Yes; 99 = Unknown	
Derived variable indicating whether patients required mechanical ventilation	der_mv	0 = No; 1 = Yes; 99 = Unknown	
Derived variable indicating time in ICU	der_ICU	0 = No; 1 = Yes; 99 = Unknown	
Derived hospitalized/not hospitalized variable	der_hosp	0 = No; 1 = Yes; 99 = Unknown	
Derived cardiovascular complication variable (see additional details)	der_CV_event_v2 (der_any_CV is the variable name in R script)	0 = No; 1 = Yes; 99=Unknown.	Derived with the following derived variables: der_hotn_comp, der_MI_comp, der_card_isch_comp, der_AFib_comp, der_VF_comp, der_arry_oth_comp, der_CMY_comp, der_CHF_comp, der_PE_comp, der_DVT_comp, der_stroke_comp, der_thrombosis_NOS_comp Coded as 1 if any of these variables is 1; coded as 0 if all these variables are 0; coded as 99 if any of variables is 99 and der_CV_event_v2 is missing;

			otherwise, NA For all listed variable here: 0=No, 1=Yes, 99=Unknown
Derived pulmonary complication variable (see additional details)	der_pulm_event (der_any_Pulm is the variable name in R script)	0 = No; 1 = Yes; 99=Unknown.	Derived with the following derived variables: der_resp_failure_comp, der_pneumonitis_comp, der_pneumonia_comp, der_ARDS_comp, der_PE_comp, der_pleural_eff_comp, der_empyema_comp Coded as 1 if any of these variables is 1; coded as 0 if all these variables are 0; coded as 99 if any of variables is 99 and der_pulm_event is missing; otherwise, NA For all listed variable here: 0=No, 1=Yes, 99=Unknown
Derived gastrointestinal complication variable (see additional details)	der_GI_event (der_any_Gast is the variable name in R script)	0 = No; 1 = Yes; 99=Unknown.	Derived with the following derived variables: der_AHI_comp, der_ascites_comp, der_BO_comp, der_bowelPerf_comp, der_ileus_comp, der_peritonitis_comp Coded as 1 if any of these variables is 1; coded as 0 if all these variables are 0; coded as 99 if any of variables is 99 and der_GI_event is missing; otherwise, NA For all listed variable here: 0=No, 1=Yes, 99=Unknown
Acute kidney injury (checkbox only)	der_AKI_comp	0 = No; 1 = Yes; 99 = Unknown	
Multisystem organ failure	der_MOF_comp	0 = No; 1 = Yes; 99 = Unknown	
Any co-infection within +/- 2 weeks of COVID-19 dx	der_coinfection_any	0 = No; 1 = Yes; 99 = Unknown	
Sepsis	der_sepsis_comp	0 = No; 1 = Yes; 99 = Unknown	
Bleeding	der_bleeding_comp	0 = No; 1 = Yes; 99 = Unknown	
DIC (without modifier of	der_DIC_comp	0 = No; 1 = Yes; 99 =	

definite/probable/possible)		Unknown	
Remdesivir as treatment for COVID-19 ever	der_rem	0 = No; 1 = Yes; 99 = Unknown	
Hydroxychloroquine as COVID-19 treatment ever	der_hcq	0 = No; 1 = Yes; 99 = Unknown	
Steroids as COVID-19 treatment ever	der_steroids_c19	0 = No; 1 = Yes; 99 = Unknown	
COVID-19 treatments other than HCQ, steroids, remdesivir	der_other_tx_c19_v2	0 = No; 1 = Yes; 99 = Unknown	
Indicates whether patient has ever had supplemental o2	der_o2_ever	0 = No; 1 = Yes; 99 = Unknown	

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Covariate description	Variable name	Covariate values	Additional Details
Race/ethnicity including Asian	*der_race_v2*	Hispanic; Non-Hispanic AAPI; Non-Hispanic Black; Non-Hispanic White; Other	
Age with imputation for categoricals	*der_age_trunc*	Years (continuous 18-89; patients noted to be greater than 89 are set to be age = 90)	
Insurance type	der_insurance	Medicaid alone; Medicare alone; Medicare/Medicaid +/- other; Other government +/- other; Private +/- other; Uninsured; Unknown	
Derived variable for smoking status collapsing the current/former smoker variables	der_smoking2	Never; Current or Former; Unknown	
Binary obesity (BMI >= 30 or checkbox checked) indicator	der_obesity	0 = No; 1 = Yes; 99 = Unknown	
Cardiovascular comorbidity (CAD, CHF, Afib, arrhythmia NOS, PVD, CVA, cardiac disease NOS)	der_card	0 = No; 1 = Yes; 99 = Unknown	
Derived variable indicating whether patient has pulmonary comorbidities	der_pulm	0 = No; 1 = Yes; 99 = Unknown	
Renal comorbidities	der_renal	0 = No; 1 = Yes; 99 =	

		Unknown	
Derived variable indicating whether patient has diabetes mellitus	der_dm2	0 = No; 1 = Yes; 99 = Unknown	
Performance Status	der_ecogcat2	ECOG 0, 1, or 2+	
Breast biomarkers combined variable	der_breast_biomarkers	1 = ER+; 2 = ER+/HER2+; 3 = HER2+; 4 = triple negative; 99 = Unknown	
Derived variable indicating cancer status (Splits remission/NED by cancer timing)	der_cancer_status_v4	0 - Remission/NED, remote; 1 - Remission/NED, recent; 2 - Active, responding; 3 - Active, stable; 4 - Active, progressing; 99 - Unknown	
Timing of cancer treatment relative to COVID-19, collapsed	der_cancer_tx_timing_v2	0 = more than 3 months; 1 = 0-4 weeks; 2 = 1-3 months (*); 88 = never or after COVID-19 diagnosis; 99 = unknown	
No cancer treatment in the 3 months prior to COVID-19	der_cancertr_none	0=No; 1=Yes; 99=Unknown	Derived with the following covariates: der_any_cyto, der_any_targeted, der_any_endo, der_any_immuno, der_any_local, der_any_other Coded as 1 if all these variables are 0; coded as 0 if any of these variables is 1; coded as 99 if any of these variables is 99; otherwise, NA
Any cytotoxic cancer treatment in the 3 months prior to COVID-19	der_any_cyto	0 = No; 1 = Yes; 99 = Unknown	
Any targeted therapy in the 3 months prior to COVID-19	der_any_targeted	0 = No; 1 = Yes; 99 = Unknown	
Any targeted therapy includes an anti-HER2 therapy in the 3 months prior to COVID-19	der_her2_3m	0 = No; 1 = Yes	Derived with der_her2, der_any_targeted. Coded as 1 if der_any_targeted is 1 and der_her2 is 1 Coded as 0 if: a. der_any_targeted is 1 and der_her2 is 0 b. der_any_targeted is 1 Otherwise, NA

			der_her2: 0 = No; 1 = Yes
Any targeted therapy includes a CDK4/6 inhibitor therapy in the 3 months prior to COVID-19	der_cdk46i_3m	0 = No; 1 = Yes	Derived with der_cdk46i, der_any_targeted. Coded as 1 if der_any_targeted is 1 and der_cdk46i is 1 Coded as 0 if: a. der_any_targeted is 1 and der_cdk46i is 0 b. der_any_targeted is 1 Otherwise, NA der_cdk46i: 0 = No; 1 = Yes
Any other targeted therapy (Not anti-HER2 / CDK4/6 inhibitor) in the 3 months prior to COVID-19	der_other_3m	0 = No; 1 = Yes	Derived with der_targeted_not_her2_cdk46i, der_any_targeted. Coded as 1 if der_any_targeted is 1 and der_targeted_not_her2_cdk46i is 1 Coded as 0 if: a. der_any_targeted is 1 and der_targeted_not_her2_cdk46i is 0 b. der_any_targeted is 1 Otherwise, NA der_targeted_not_her2_cdk46i: 0 = No; 1 = Yes
Any endocrine therapy in the 3 months prior to COVID-19	der_any_endo	0 = No; 1 = Yes; 99 = Unknown	
Any immunotherapy in the 3 months prior to COVID-19	der_any_immuno	0 = No; 1 = Yes; 99 = Unknown	
Any local therapy (surgery or RT) within 3 months	der_any_local	0 = No; 1 = Yes; 99 = Unknown	
Any other cancer therapy in the 3 months prior to COVID-19	der_any_other	0 = No; 1 = Yes; 99 = Unknown	
Region of patient residence with ex-US collapsed	der_region_v2	Non-US; Other; Undesignated US; US Midwest; US Northeast; US South; US West	
Trimester and year of	der_tri_rt_dx	T1 2020; T2 2020; T3	

diagnosis, using the most recent side of the interval as anchor		2020; T1 2021	
What type of area does the patient primarily reside in?	urban_rural[1]	1, Urban (city) | 2, Suburban (town, suburbs) | 3, Rural (country) | 88, Other | 99, Unknown	
The type of health care center providing the patient's data	der_site_type	AMC = academic medical center; CP = community practice; TCC = tertiary care center	
Initial Severity and Course of Illness	severity_of_covid_19_v2[1]	1, Mild (no hospitalization required) | 2, Moderate (hospitalization indicated) | 3, Severe (ICU admission indicated) | 99, Unknown	
Derived treatment intent	der_tr_intent	Unknown Treatment; Not on Treatment; Palliative; Curative; Missing Unknown Treatment and Missing were collapsed for analysis	Derived with der_anytx and treatment_intent: Coded as "Unknown Treatment" if der_anytx is NA or 99; Coded as "Not on Treatment" if der_anytx is 0 Coded as "Palliative" if der_anytx is 1 and treatment_intent is 2 Coded as "Curative" if der_anytx is 1 and treatment_intent is 1 Otherwise, Missing der_anytx: 0 = No; 1 = Yes; 99 = Unknown Treatment_intent: 1, Curative | 2, Palliative | 99, Unclear or unknown
Most recent line of cancer treatment, including systemic and non-systemic therapies	der_txline	Untreated in last 12 months; Curative NOS; First line; Non-curative NOS; Other; Second line or greater; Unknown	
Hematologic malignancy indicator	der_heme	0 = No; 1 = Yes	

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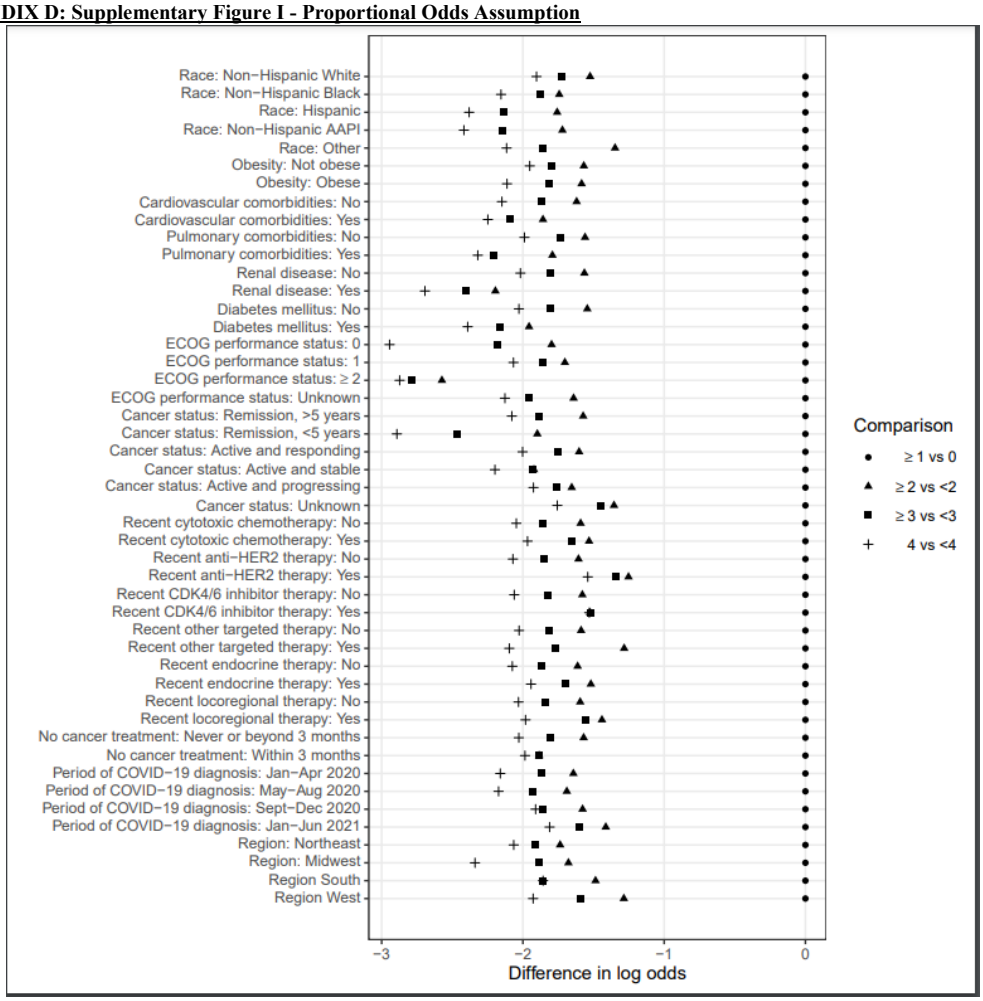
Other covariate related to cohort selection for analysis	Variable name	Covariate values	Covariate description
Sex **(Recode other/prefer not to**	*der_sex*	*Male, Female*	

say gender --> missing)			
Breast cancer	der_Breast	0 = No; 1 = Yes	
Cancer type of second malignancy. **If the patient has more than two malignancies, please select the second-most recently diagnosed cancer type. If unknown or unclear, please specify in the free text box below**	cancer_type_2[1]	'' indicates no second malignancy.	
Region of patient residence with US and ex-US collapsed	der_region_v3	Non-US; Other; US	

New covariate request – 2-5-22

New covariate	Variable name	Covariate values	Covariate description
MBC vs non-MBC	der_metastatic	*0 = No; 1 = Yes; 99 = Unknown*	*Metastatic cancer status (only applicable to solid tumors/lymphoma)*
MBC site of metastasis	der_met_bone	0 = No; 1 = Yes; 99 = Unknown	Metastatic to bone
MBC site of metastasis	der_met_liver	0 = No; 1 = Yes; 99 = Unknown	Metastatic to liver
MBC site of metastasis	der_met_lung_v2	0 = No; 1 = Yes; 99 = Unknown	Metastatic to lung

APPENDIX D: Supplementary Figure I - Proportional Odds Assumption



915 **APPENDIX E**

Supplement Table 1. Unadjusted rates of outcomes after COVID-19 diagnosis by cancer status

	NED>5 Years	NED<5 Years	Active and Responding	Active and Stable	Active and Progressing	Missing/ Unknown	Total
	n[a] (%)	n[a] (%)	n[a] (%)	n[a] (%)	n[a] (%)	n[a] (%)	n[a] (%)
Outcomes							
Total all-cause mortality [b]	40 (11)	12 (3)	12 (7)	11 (7)	37 (38)	11 (9)	123 (9)
30-day all-cause mortality [c]	29 (8)	10 (2)	10 (6)	4 (2)	27 (28)	9 (7)	89 (6)
Received mechanical ventilation [b]	20 (5)	13 (3)	9 (5)	7 (4)	12 (12)	8 (7)	69 (5)
Admitted to an intensive care unit [b]	35 (10)	25 (6)	13 (8)	8 (5)	18 (19)	12 (10)	111 (8)
Admitted to the hospital [b]	163 (43)	129 (29)	54 (31)	57 (34)	70 (72)	39 (32)	512 (37)

[a]N is based on non-missing data

[b]Included in primary ordinal COVID-19 severity outcome.

[c]Secondary outcome.

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936 **APPENDIX F**

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Supplementary Table IIA: Baseline characteristics of female patients with MBC	
	MBC (N=233)
Age, years[a]	
Median [IQR]	58.0 [49.8, 68.3]
Race/Ethnicity	
Non-Hispanic White	107 (46%)
Non-Hispanic Black	56 (24%)
Hispanic	50 (21%)
Non-Hispanic AAPI	10 (4%)
Other	10 (4%)
Smoking Status	
Never	162 (70%)
Current or Former	66 (28%)
Missing/unknown	5 (2%)
Obesity	
No	139 (60%)
Yes	93 (40%)
Comorbidities[b]	
Cardiovascular	42 (18%)
Pulmonary	37 (16%)
Renal Disease	16 (7%)
Diabetes mellitus	52 (22%)
Missing/unknown	3 (1%)
ECOG Performance Status	
0	63 (27%)
1	84 (36%)
2+	42 (18%)
Unknown	44 (19%)
Missing	0 (0%)
Receptor status	
HR+/HER2-	98 (42%)
HR+/HER2+	53 (23%)
HR-/HER2+	26 (11%)
Triple Negative	33 (14%)
Missing/unknown	23 (10%)
Cancer Status	

Active and responding	55 (24%)
Active and stable	78 (33%)
Active and progressing	74 (32%)
Unknown	25 (11%)
Missing	0 (0%)
Metastatic sites (MBC)	
Lung	65 (28%)
Bone	135 (58%)
Liver	61 (26%)
Missing/unknown	19 (8%)
Timing of anti-cancer therapy	
Never/After COVID-19	X*
0-4 weeks	189 (81%)
1-3 months	14 (6%)
>3 months	19 (8%)
Missing/unknown	11 (5%)*
Modality of active anti-cancer therapy[b,c]	
None	24 (10%)
Cytotoxic Chemotherapy	114 (49%)
Targeted Therapy	115 (49%)
Endocrine Therapy	98 (42%)
Immunotherapy	17 (7%)
Local (Surgery/Radiation)	27 (12%)
Other	6 (3%)
Missing/unknown	6 (3%)
Region	
Northeast	97 (42%)
Midwest	44 (19%)
South	34 (15%)
West	56 (24%)
Undesignated	2 (1%)
Period of COVID-19 diagnosis	
Jan-Apr 2020	33 (14%)
May-Aug 2020	101 (43%)
Sept-Dec 2020	52 (22%)
Jan-Aug 2021	45 (19%)
Missing/unknown	2 (1%)
Area of patient residence	
Urban	103 (44%)
Suburban	80 (34%)
Rural	12 (5%)
Missing/unknown	38 (16%)
Treatment center characteristics	

Academic Medical Center	43 (18%)
Community Practice	63 (27%)
Tertiary Care Center	127 (55%)
Missing/unknown	0 (0%)
Severity of COVID19	
Mild	126 (54%)
Moderate	93 (40%)
Severe	13 (6%)
Missing/Unknown	1 (<1%)

***Cells combined to mask N<5 according to CCC19 low count policy**

[a]Age was truncated at 90 years.

[b]Percentages could sum to >100% because categories are not mutually exclusive.

[c]Within 3 months of COVID-19 diagnosis.

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Supplement Table IIB: Unadjusted rates of outcomes after COVID-19 diagnosis in females with MBC

	n[f] (%)
Outcomes	
Total all-cause mortality [a]	45 (19)
30-day all-cause mortality [b]	28 (12)
Received mechanical ventilation [a]	20 (9)
Admitted to an intensive care unit [a]	29 (12)
Admitted to the hospital [a]	124 (53)
Clinical Complications	
Any cardiovascular complication [c]	48 (21)
Any pulmonary complication [d]	86 (37)
Any gastrointestinal complication [e]	13 (6)
Acute kidney injury	32 (14)
Multisystem organ failure	12 (5)
Superimposed infection	32 (14)
Sepsis	28 (12)
Any bleeding	8 (3)
Interventions	
Remdesivir	35 (15)
Hydroxychloroquine	25 (11)
Corticosteroids	65 (29)
Covid Other	45 (20)
Supplemental oxygen	84 (37)

[a]Included in primary ordinal COVID-19 severity outcome

[b]Secondary outcome

[c]Cardiovascular complication includes hypotension, myocardial infarction, other cardiac ischemia, atrial fibrillation, ventricular fibrillation, other cardiac arrhythmia, cardiomyopathy, congestive heart failure, pulmonary embolism (PE), deep vein thrombosis (DVT), stroke, thrombosis NOS complication.

[d]Pulmonary complication includes respiratory failure, pneumonitis, pneumonia, acute respiratory distress syndrome (ARDS), PE, pleural effusion, empyema.

[e]Gastrointestinal complication includes acute hepatic injury, ascites, bowel obstruction, bowel perforation, ileus, peritonitis

[f]N is based on non-missing data

APPENDIX G

Supplement Table III: Adjusted Associations of Race Factors with COVID-19 Severity Outcome.

	COVID-19 severity		
	OR (95% CI)	Point Value E estimates[a]	Lower bound E values[a]
Race (Ref: NHW)			
Black	1.74 (1.24- 2.45)	1.97	1.47
Hispanic	1.38 (0.93- 2.05)	1.63	1.00
AAPI	3.40 (1.70- 6.79)	3.09	1.93
Other	2.97 (1.71- 5.17)	2.84	1.94

[a] These values were calculated based on the formula for logistic regression

APPENDIX H:

Supplement Table IVA: Male patients with breast cancer and COVID-19: Baseline Characteristics

Total	**25 (100%)**
Age, years[a]	
Median [IQR]	67.0 [60 - 75]
Race/Ethnicity	
NHW	13 (52%)
Black	8 (32%)
Hispanic	<5 (<20%)
AAPI	0 (0%)
Other	<5 (<20%)
Smoking Status	
Never	18 (72%)
Current or Former	7 (28%)
Obesity	
No	12 (48%)
Yes	13 (52%)
Comorbidities[b]	
Cardiovascular	6 (24%)
Pulmonary	5 (20%)
Renal Disease	<5 (<20%)
Diabetes mellitus	11 (44%)
ECOG Performance Status	
0	5 (20%)
1	10 (40%)
2+	X*
Unknown	10 (40%)*
Receptor status	
HR+/HER2-	18 (72%)
HR+/HER2+	5 (20%)
HR+/HER2+	X*
Triple Negative	0 (0%)
Missing/unknown	2 (8%)*
Cancer Status	
Remission or NED, >5 years	<5 (<20%)
Remission or NED, <5 years	6 (24%)
Active and responding	<5 (<20%)
Active and stable	<5 (<20%)
Active and progressing	5 (20%)

Unknown	3 (12%)
Timing of anti-cancer therapy	
Never/After COVID-19	<5 (<20%)
0-4 weeks	17 (68%)
1-3 months	0 (0%)
>3 months	<5 (<20%)
Missing/unknown	1 (4%)
Modality of active anti-cancer therapy [b,c]	
None	7 (28%)
Chemotherapy	6 (24%)
Targeted Therapy	6 (24%)
Endocrine Therapy	10 (40%)
Immunotherapy	0 (0%)
Local (Surgery/Radiation)	<5 (<20%)
Other	0 (0%)
Missing/unknown	1 (4%)
Region	
Northeast	11 (44%)
Midwest	<5 (<20%)
South	<5 (<20%)
West	7 (28%)
Undesignated	0 (0%)
Period of COVID-19 diagnosis	
Jan-Apr 2020	10 (40%)
May-Aug 2020	9 (36%)
Sept-Dec 2020	5 (20%)
Area of patient residence	
Urban	9 (36%)
Suburban	8 (32%)
Rural	0 (0%)
Missing/unknown	8 (32%)
Severity of COVID19	
Mild	11 (44%)
Moderate/Severe	14 (56%)

***Cells combined to mask N<5 according to CCC19 low count policy**

[a] Age was truncated at 90 years.

[b] Percentages could sum to >100% because categories are not mutually exclusive.

[c] Within 3 months of COVID-19 diagnosis.

Variable Categories with one to five cases are masked by replacing with N < 5 according to CCC19 policy

Suppl Table IVB: Unadjusted rates of outcomes after COVID-19 diagnosis among males with BC	
Outcomes	
Total all-cause mortality	5 (20)
30-day all-cause mortality	5 (20)
Received mechanical ventilation	<5 (<20%)
Admitted to an intensive care unit	<5 (<20%)
Admitted to the hospital	15 (60)
Clinical Complications	
Any cardiovascular complication [a]	<5 (<20%)
Any pulmonary complication [b]	12 (48)
Any gastrointestinal complication [c]	0 (0%)
Acute kidney injury	<5 (<20%)
Multisystem organ failure	<5 (<20%)
Superimposed infection	<5 (<20%)
Sepsis	<5 (<20%)
Any bleeding	<5 (<20%)
Interventions	
Remdesivir	<5 (<20%)
Hydroxychloroquine	7 (28)
Corticosteroids	<5 (<20%)
Other	9 (36)
Supplemental oxygen	12 (48)

Variable Categories with one to five cases are masked by replacing with N < 5 according to CCC19 policy

[a] Cardiovascular complication includes hypotension, myocardial infarction, other cardiac ischemia, atrial fibrillation, ventricular fibrillation, other cardiac arrhythmia, cardiomyopathy, congestive heart failure, pulmonary embolism (PE), deep vein thrombosis (DVT), stroke, thrombosis NOS complication.

[b] Pulmonary complication includes respiratory failure, pneumonitis, pneumonia, acute respiratory distress syndrome (ARDS), PE, pleural effusion, empyema.

[c] Gastrointestinal complication includes acute hepatic injury, ascites, bowel obstruction, bowel perforation, ileus, peritonitis

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APPENDIX I:

List of Participants by Institution

Alphabetical list of participants by institution that contributed at least one record to the analysis.

Bolded = site PI/co-PIs; site co-investigators are listed alphabetically by last name.

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