

## Scientific Article

# Impact of the Coronavirus Disease of 2019 Pandemic on Radiation Oncology Clinical Decision Making in a High-Prevalence Environment



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## Abstract

**Purpose:** This study aimed to define how the coronavirus disease of 2019 (COVID-19) pandemic affected the role, timing, and delivery of radiation therapy (RT) in a high-prevalence region at the height of the initial U.S. outbreak.

**Methods and Materials:** We performed a retrospective review of all patients seen at 3 radiation oncology departments within the Rutgers Robert Wood Johnson Barnabas Health system in New Jersey during the initial COVID-19 surge. The primary endpoints were to define and quantify COVID-related, radiation-specific care changes, and identify predictive factors of experiencing COVID-related care changes.

**Results:** A total of 545 patients with cancer were seen during the study period, 99 of whom (18.1%) experienced  $\geq 1$  COVID-related care change. RT delays were the most common, accounting for 51.5% of all care changes. Physician-directed delays accounted for 41.2% of RT delays, and patient fears, COVID testing, and access barriers were responsible for 27.5%, 17.6%, and 13.7%, respectively. Patient age ( $P = .040$ ), intent of treatment ( $P = .047$ ), and cancer type ( $P < .001$ ) were significantly associated with experiencing a COVID-related care change, as we found that older, curative intent and patients with rectal cancer were more likely to experience care changes. On multivariate analysis, patient age remained significant when controlling for treatment intent and cancer type.

**Conclusions:** Our study provides a perspective on how care was adapted to protect patients with cancer during a pandemic while maximizing disease control. The positive correlation between age and likelihood of care changes may reflect extra precaution taken with older patients given their vulnerability to severe COVID illness. The lower observed likelihood of COVID-related care changes among patients undergoing palliative RT may reflect either the more urgent needs addressed by palliative RT or simply be logistical, because palliative radiation is often delivered in short courses with less exposure risk. Assessing adaptations others have implemented and monitoring how they affect patient outcomes will be crucial.

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## Introduction

The rampant spread of the coronavirus disease of 2019 (COVID-19), a pulmonary illness caused by the novel severe acute respiratory syndrome coronavirus 2, has resulted in a global pandemic that continues to devastate communities around the world and upend daily life. Since the initial outbreak in Wuhan, China in December 2019, the severe acute respiratory syndrome coronavirus 2 has infected >24 million people in 216 countries or territories, costing >800,000 lives.<sup>1</sup>

Navigating this public health crisis has been particularly challenging for patients with cancer, who are not only grappling with the burden of their diagnosis but many who are also immunocompromised and thus more susceptible to severe COVID-19 illness.<sup>2,3</sup> A nationwide analysis in China showed that patients with cancer had a 3.5-fold increased risk of requiring mechanical ventilation or intensive care unit admission relative to patients without cancer.<sup>2</sup>

Some patients with cancer elected to avoid treatment due to fear of infection while others faced increased barriers to seek care due to resource constraints caused by surges in COVID-19 hospital admissions.<sup>4</sup> Access to cancer treatment may have been particularly affected for patients in the United States' New York metropolitan area, which was among the hardest-hit regions in the world.<sup>5</sup>

The Rutgers Robert Wood Johnson Barnabas Health (RWJBH) system, one of the largest health systems in the state of New Jersey, faced a large influx of COVID-19 admissions during the height of the initial US pandemic, with >900 COVID-19 admissions at RWJBH Hospital alone between March 11, 2020 and May 29, 2020.<sup>5,6</sup> To meet the needs of patients infected with COVID-19, an executive order by the Governor of New Jersey suspended all elective surgeries from March 27, 2020 to May 26, 2020, resulting in the closure or redeployment of 14 inpatient units at RWJBH, including the surgical oncology unit.<sup>7,8</sup>

Working with a vulnerable patient population within a resource-strained health care environment, the New Jersey oncology community joined hospital systems around the world in facing the unprecedented task of weighing the benefits of vital cancer treatment against the risks of patient exposure to a potentially deadly virus. Although professional societies and individual hospitals have issued multiple sets of guidelines on how cancer care can be modified during the pandemic, the actual impact of the pandemic on patients seeking radiation therapy (RT) and treatment decisions by radiation oncologists has not been well explored.<sup>9-13</sup> Prior studies examining the impact of the pandemic on cancer care have been largely restricted to patient survey data or primarily focused on the rate of adoption of telemedicine.<sup>4,13-17</sup>

Based on Rutgers RWJBH's location at the epicenter of the initial US outbreak, we sought to systematically evaluate the impact of the COVID-19 pandemic on RT-related care at the Rutgers RWJBH system. We hypothesized that the role, timing, and delivery of radiation were modified for a significant proportion of patients with cancer due to a combination of patient fear, physician efforts to minimize patient exposure, and the reallocation of hospital staff and resources. We also aimed to identify predictors of experiencing a radiation-related care change during the pandemic.

## Methods and Materials

We performed an institutional review board-approved, multi-institutional, retrospective review of all patients seen at 3 radiation oncology departments within the Rutgers RWJBH system between March 9, 2020, and June 15, 2020, corresponding to the peak of the pandemic in New Jersey. Patients were followed as of March 9, 2020, because this was the date the Governor of New Jersey declared a state of emergency.<sup>18</sup> New Jersey entered stage 2 of its reopening on June 15, 2020; therefore, this date served as an appropriate endpoint for the study period.<sup>19</sup> The study cohort consisted of patients who were seen in consultation (including telemedicine consultations), undergoing treatment planning, or on active treatment during the period of interest. Patients seen in consultation, regardless of whether they proceeded with radiation, were included. We excluded patients who completed treatment before the period of interest and were only seen for routine a follow-up visit during the study period. We also excluded patients who presented for benign conditions, such as stereotactic radiosurgery for trigeminal neuralgia.

Within the cohort, patients who experienced any alteration in care relating to RT as a result of the COVID-19 pandemic were either identified through a review of patient charts or prospectively captured by a group of attending radiation oncologists participating in the project. A care change was only considered COVID-related when specifically indicated in a patient's chart. Radiation-related care changes were classified into the following categories: RT delay/deferment, RT omission, RT fractionation change, brachytherapy-specific change, RT course disruption, and RT in lieu of surgery.

RT omission indicated that patients either declined the recommended treatment or were advised by their radiation oncologist against undergoing radiation because the risk of exposure was thought to outweigh the benefit of treatment. RT course disruption refers to a pause or premature discontinuation in RT due to patient fear of exposure, the need for COVID testing, or a positive COVID test result. The RT-in-lieu-of-surgery category includes patients who were treated with definitive

radiation as opposed to upfront surgery or patients who, before COVID, may not have been treated with radiation but who received RT due to the limited access to certain surgical procedures. We defined a brachytherapy-specific change as an omission of a brachytherapy boost, replacement of a brachytherapy boost with an external beam RT (EBRT) boost, or a change in the timing of a brachytherapy boost in relation to the EBRT course.

Patient, clinical, and treatment characteristics were collected, including age, cancer type, intent (palliative or curative), overall stage, presence of comorbidities associated with a higher risk of severe COVID illness per the Centers for Disease Control and Infection (CDC),<sup>20</sup> performance status, and receipt of concurrent chemotherapy. Descriptive statistics were performed to determine the percentage of patients who experienced a COVID-related change in care within the entire cohort. A CDC-defined comorbidity linked with severe COVID illness<sup>5</sup> was classified as the presence of  $\geq 1$  of the following illnesses: Diabetes, heart failure, coronary artery disease, chronic obstructive pulmonary disease, chronic kidney disease, or obesity. To objectively measure the variable impact of the pandemic on different cancer types, the frequency of COVID-related changes that were not prompted by either patient fear or the need for COVID testing was calculated for each cancer type. Univariate and multivariate analyses with *t* test (age),  $\chi^2$  test (all other univariate analyses), or bivariate logistic regression (all multivariate analysis) were performed to evaluate the association between patient, clinical, and treatment parameters and the risk of experiencing a COVID-related care change. All *P* values < .05 were considered significant. All data analyses were performed using SPSS statistical software package version 27 (IBM) or MATLAB (Mathworks).

## Results

We identified all 545 patients with cancer seen in consultation, undergoing treatment planning, or on active RT at 3 radiation oncology departments in the Rutgers RWJBH system from March 8, 2020, to June 15, 2020 (Table 1). Ninety-nine patients (18.1%) experienced at least 1 radiation-specific care change attributable to the COVID-19 pandemic. RT delays were the most common, accounting for 51.5% of all COVID-related care changes (n = 51), followed by RT fractionation changes (n = 14), RT omissions (n = 11), RT course disruptions (n = 10), RT in lieu of surgery (n = 9), and brachytherapy-specific changes (n = 9). Four patients in the cohort tested positive for COVID-19 during the period of interest. Three of these patients tested positive before initiating RT, resulting in RT delays, and 1 patient tested positive in the middle of RT, resulting in an RT course disruption.

**Table 1** Baseline patient characteristics

Characteristic	No. (%)
N	545
Age, years, median (range)	63 (18-94)
Intent	
Curative	440 (80.7)
Palliative	105 (19.3)
Cancer type	
Breast	137 (25.1)
Metastases	88 (16.1)
Prostate	74 (13.6)
Head and neck	47 (8.6)
Endometrial	31 (5.7)
Hematologic	20 (3.7)
Hepatobiliary	19 (3.5)
Meningioma	18 (3.3)
Lung	17 (3.1)
Glioma	16 (2.9)
Cervical	14 (2.6)
Skin	11 (2.0)
Rectal	10 (1.8)
Other	43 (7.9)
Stage	
I	231 (42.4)
II	101 (18.5)
III	72 (13.2)
IV	141 (25.9)
Concurrent chemotherapy	
Yes	125 (22.9)
No	348 (63.9)
Comorbidities associated with severe coronavirus disease illness	
Yes	132 (24.2)
No	392 (71.9)
Eastern Cooperative Oncology Group performance status score	
0	164 (30.1)
1	157 (28.8)
2	47 (8.6)
3	25 (4.6)
4	9 (1.7)
Missing	143 (26.2)

Furthermore, 41.2% of all RT delays were directed by the physician to minimize patient exposure to the health care setting. Patient fear, the need for COVID testing, and barriers to accessing care were responsible for 27.5%, 17.6%, and 13.7% of RT delays, respectively. Examples of health care access barriers that contributed to RT delays include challenges with scheduling fiducial placement for prostate RT (n = 3), disruptions in insurance coverage (n = 3), limited availability of dentists to obtain necessary tooth extractions before head and neck (H&N) radiation (n = 1), and delays in percutaneous endoscopic gastro-tomy tube placements before H&N radiation due to operation room closures (OR; n = 1). One patient with esophageal cancer who was uninsured and unable to

**Table 2** Univariate and multivariate analyses

Characteristic	No change, no. (%)	Change*, no. (%)	P-value
Age, years, mean	61.0	64.8	.040
Intent			.047
Curative	389 (88.4)	51 (11.6)	
Palliative	100 (95.2)	5 (4.8)	
Cancer type			<.001
Bladder	5 (100)	0 (0.0)	
Breast	126 (92)	11 (8.0)	
Cervix	12 (85.7)	2 (14.3)	
Endometrial	27 (87.1)	4 (12.9)	
Glioma	13 (81.3)	3 (18.8)	
Head and neck	41 (87.2)	6 (12.8)	
Hematologic	18 (90.0)	2 (10.0)	
Hepatobiliary	19 (100)	0 (0.0)	
Lung	17 (100)	0 (0.0)	
Meningioma	16 (88.9)	2 (11.1)	
Pancreas	9 (100)	0 (0.0)	
Prostate	60 (81.1)	18.9 (0.0)	
Rectal	3 (30.0)	7 (70.0)	
Skin	10 (90.9)	1 (9.1)	
Other	28 (95.1)	1 (4.9)	
Stage			.096
I	201 (87.0)	30 (13.0)	
II	93 (92.1)	8 (7.9)	
III	62 (86.1)	10 (13.9)	
IV	133 (94.3)	8 (5.7)	
Concurrent chemotherapy			.634
Yes	358 (90.2)	39 (9.8)	
No	131 (88.5)	17 (11.5)	
Comorbidities associated with severe coronavirus disease illness			.876
Yes	353 (89.8)	40 (10.2)	
No	136 (89.5)	16 (10.5)	
Eastern Cooperative Oncology Group performance status score			.622
0	145 (88.4)	19 (11.6)	
1	140 (89.2)	17 (10.8)	
2	43 (91.5)	4 (8.5)	
3	24 (96.0)	1 (4.0)	
4	9 (100)	0 (0.0)	

\* Number of patients experiencing COVID-related care changes, excluding changes driven by patient fear or the need for coronavirus disease testing.

enroll for charity care in a timely fashion was admitted to the hospital to initiate inpatient chemoradiation without further delay.

Among all patients who experienced an RT delay, 41% were started on systemic therapy before the initiation of RT. Five patients who chose to delay their computed tomography simulation for adjuvant breast radiation due to fear of COVID exposure were started on adjuvant hormone therapy (tamoxifen or anastrozole) soon after breast conservation surgery. Twelve patients who experienced a physician-directed delay in RT were started on systemic therapy in the interim. For 9 of these 12 patients, the treatment paradigm was significantly modified so that a full course of systemic therapy alone

could be completed before starting RT. For example, 2 patients with unfavorable intermediate risk prostate cancer completed 6 months of androgen deprivation therapy (ADT) before starting radiation, and 7 patients with rectal cancer received either a full course of adjuvant FOLFOX chemotherapy before adjuvant chemoradiation or underwent total neoadjuvant therapy (TNT) with FOLFOX chemotherapy administered before chemoradiation.

Among the 11 patients for whom RT was omitted, 8 elected to forgo RT and 3 were advised against RT by their radiation oncologist. All 3 patients who were advised against RT were being evaluated for adjuvant RT for a central nervous system malignancy. Observation was

recommended for 2 patients with grade 2 meningioma after a gross total resection because the risk of COVID exposure was thought to outweigh the local control benefit conferred by adjuvant RT. One elderly patient who underwent a gross total resection for an isocitrate dehydrogenase-mutated, methyl guanine methyl transferase (MGMT) hypermethylated glioblastoma underwent adjuvant chemotherapy alone without concurrent radiation.

We identified 7 patients who may have been spared radiation in the pre-COVID setting but who received RT as part of their treatment course due to limited surgical options during the pandemic. One patient with stage I glottic cancer whose first preference was to undergo transoral laser microsurgery instead received definitive RT alone. Two patients with gynecologic malignancies underwent treatment with definitive RT as opposed to a hysterectomy, one with medically operable endometrial carcinoma and the other with Stage IB cervical squamous cell carcinoma. Two patients with breast cancer whose initial management preference was total mastectomy with autologous reconstruction were instead managed with breast conservation therapy encompassing whole breast RT due to limited access to reconstructive surgery. Two patients with H&N cancer with positive margins after initial surgical resection underwent postoperative chemoradiation instead of reexcision surgery due to OR closures. We also identified 2 additional patients who typically would have received upfront surgery followed by adjuvant radiation but were instead managed with upfront radiation due to OR closures. Both patients had T4a glottic cancer and were initially recommended a total laryngectomy followed by adjuvant radiation, but instead pursued a larynx preservation approach with definitive chemoradiation.

As a result of the pandemic, 14 patients underwent a more hypofractionated regimen than would typically have been performed at our institution. As an example, 4 patients with high-risk prostate adenocarcinoma, who are typically treated at our institution with conventional fractionation to 79.2 Gy in 44 fractions, received moderate hypofractionation to 70.2 Gy in 26 fractions. For 3 patients, the fractionation for palliative radiation to bone metastases was converted from 20 Gy in 5 fractions to 8 Gy in 1 fraction. Two patients with locally advanced breast cancer underwent hypofractionated regional nodal irradiation to 42.56 Gy in 16 fractions. For 2 elderly patients with glioblastoma, the pandemic was noted to be a contributing factor in the decision to recommend hypofractionated adjuvant chemoradiation to 40 Gy in 15 fractions. Preoperative short-course radiation to 25 Gy in 5 fractions was implemented for 1 patient with rectal cancer, and another patient with multiple myeloma received treatment to a bony lesion to 8 Gy in 1 fraction as opposed to our standard regimen of 20 Gy in 10 fractions.

We identified 9 patients who underwent a change in brachytherapy-specific care. Four patients with high-risk prostate cancer who were initially planned for combined modality treatment with EBRT to the whole pelvis followed by a brachytherapy boost were instead managed with EBRT to the pelvis followed by a hypofractionated EBRT boost. For 2 patients with prostate cancer who successfully completed combined modality treatment during the pandemic, their high-dose-rate brachytherapy boost was deliberately scheduled before the EBRT course in anticipation of upcoming OR closures. Vaginal cuff brachytherapy was omitted for 2 patients with high-intermediate risk endometrial carcinoma who would typically have been treated with EBRT plus brachytherapy.

The frequency of COVID-related care changes that were not prompted by either patient fear or the need for COVID testing varied by cancer type (Table 2). Seventy percent of all patients with rectal cancer who were seen during the study period experienced a physician-directed COVID-related care change, most commonly a change in the sequencing of treatment such that treatment was begun with neo-adjuvant FOLFOX rather than chemoradiation with a plan for chemoradiation to follow. In addition, 18.1% of patients with prostate cancer experienced changes to the radiation plan, including short-term delays in computed tomography simulations directed by the physician, administration of prolonged courses of ADT (>2 months) before RT, increased hypofractionation, and omission or change in timing of high-dose brachytherapy boost treatments. Furthermore, 18.8% of patients with glioma, 14.2% with cervical cancer, 13% with H&N cancer, and 12.9% with endometrial cancer experienced an alteration in care driven by either clinical decision making of the individual radiation oncologist or hospital resource constraints. In contrast, no patients with primary lung carcinoma or an upper gastrointestinal malignancy, including esophageal, hepatobiliary, or pancreatic cancer, experienced a COVID-related care change beyond those related to patient fear or the need for COVID testing.

Patient age, intent of treatment, and cancer type were significant predictors of experiencing a COVID-related care change (Table 2). The mean age of patients who experienced a COVID-related change was 64.8 years, and the mean age of those who did not experience a COVID-related care change was 61.0 years ( $P = .040$ ). Patients undergoing curative intent treatment were also significantly more likely to undergo a COVID-related care change than those undergoing palliative therapy (20.6% vs. 7.6%;  $P = .047$ ). Finally, we also found, relative to other cancer types, that rectal cancer was significantly associated with experiencing a COVID-related care change ( $P < .001$ ). On multivariate analysis, patient age remained significant when controlling for intent of treatment and cancer type. Notably, the presence of CDC-

defined comorbidities linked with severe COVID illness,<sup>20</sup> performance status, and overall stage did not demonstrate clear associations with the chance of experiencing a COVID-related care change.

## Discussion

Despite the flurry of guidelines released since the start of 2020 on how RT should be modified during the COVID-19 pandemic, the extent to which radiation-related care was actually altered for patients with cancer at the height of the pandemic in COVID-19 hotspots remains unclear. We found that nearly one-fifth of all patients seen at 3 radiation oncology departments located in the epicenter of the initial U.S. outbreak experienced at least 1 change in the role, timing, or delivery of RT.

An RT delay was the most common COVID-related care change experienced by patients in our study, accounting for 49% of all documented changes. In addition, 9.3% of patients experienced a delay in RT, which is similar to the frequency of RT delays reported in patient surveys conducted during the pandemic.<sup>4,17</sup> For example, in a survey of 600 patients with breast cancer in the United States who were seeking care or on active treatment from April 28, 2020, to June 7, 2020, 5% of respondents indicated that they experienced a delay in RT specifically because of the pandemic.<sup>4</sup> In another survey of >1200 patients with cancer conducted by the American Cancer Society Cancer Action Network from April 30, 2020, to May 14, 2020, 37% of patients with cancer reported a delay in some aspect of oncologic care.<sup>17</sup> In an European Society of Therapeutic Radiology and Oncology survey examining the impact of the COVID-19 pandemic on European radiation oncology centers, 65% of the surveyed departments reported a decline in patient volume primarily due to delays or deferrals.<sup>21</sup>

Although several patients in our cohort elected to delay or defer ER, patient hesitation to present to the health care setting was responsible for only a minority of RT delays. Our finding that patient fears were not the dominant factor contributing to RT delays parallels the attitudes expressed by patients with breast cancer in an Italian survey in which 72% of respondents ranked compromised access to timely cancer care as their biggest fear during the pandemic, as opposed to just 11.6% of patients whose principle fear was hospitalization secondary to COVID-19 infection.<sup>15</sup> In fact, the most common cause of delayed treatment in our study was the independent clinical judgment of the patient's radiation oncologist, with physician-directed delays accounting for nearly half of all delays. In the American Cancer Society Cancer Action Network survey, 64% of patients with cancer who experienced a COVID-related care change reported that the change was prompted by their health care provider,

mirroring our finding that physician discretion was the largest driver of treatment delays.<sup>17</sup>

For 9 patients in our study, their radiation and medical oncologists made a joint evidence-based decision to modify the sequencing of RT and systemic therapy such that a full course of systemic therapy alone was administered before starting RT. The adoption of TNT for patients with rectal cancer in our cohort, which entails the delivery of a full course of FOLFOX chemotherapy before radiation, can be justified by the findings of the phase 3 RAPIDO trial, which demonstrated improved rates of pathologic complete response, locoregional control, and distant metastases with a TNT approach compared with upfront preoperative chemoradiation.<sup>22</sup> The decision to administer a prolonged course of ADT alone (>2 months) before RT for multiple patients with prostate cancer in our cohort is supported by a phase 3 study that revealed no difference in biochemical relapse-free survival between patients who underwent 4 months of ADT before RT versus those who started ADT concurrently with RT.<sup>23</sup> Furthermore, in a recently published analysis examining the implications of altering the sequence of prostate RT and ADT during the pandemic, delaying RT to 120 to 180 days after starting ADT was not associated with a decrease in overall survival.<sup>24</sup>

Some RT delays in our study illustrated the impact of new health care access barriers imposed by the COVID-19 pandemic. For example, some procedures that can be required before the initiation of RT (eg, fiducial marker and percutaneous endoscopic gastrostomy tube placements) were harder to schedule due to the redeployment of hospital staff and resources during the pandemic. In addition, multiple patients in our cohort experienced RT delays due to loss of insurance coverage or increased difficulty obtaining charity care during the height of the pandemic, with 1 patient forced to start chemoradiation in an inpatient setting. According to the Economic Policy Institute, nearly 12 million people lost employer-sponsored health insurance between February and July of 2020, and the rate of RT delays observed in our study partially reflects the ripple effect of this unprecedented economic disruption on timely access to vital oncologic care.<sup>25</sup>

Beyond delaying treatment initiation, radiation oncologists employed multiple additional strategies to minimize patient exposure to the health care setting, including hypofractionation, elimination of a brachytherapy boost, or omission of RT altogether. Notably, the increased use of hypofractionation in our cohort is aligned with multiple recommendations released by professional cancer societies during the pandemic.<sup>9-11</sup> Physician decisions to omit RT were either guided by published phase 3 data or based on ongoing randomized trials. For example, the recommendation to forgo RT for the elderly patient with MGMT hypermethylated glioblastoma is supported by the NOA-8 trial, which demonstrated superior event-free

survival among MGMT methylated patients who underwent temozolomide alone versus radiation alone.<sup>26</sup>

Like many institutions across the country, the pandemic triggered a decline in the total volume of patients on treatment at Rutgers RWJBH, as the average number of patients on treatment each day fell by 33% from January 2020 to April 2020. However, although the overall patient volume dropped, we identified a specific subgroup of patients for whom the role of radiation expanded as a direct result of the paucity of available surgical interventions during the pandemic.<sup>27</sup>

The impact of COVID-19 on radiation-related care varied noticeably across different tumor types. For example, although the pandemic significantly altered the treatment paradigm for 70% of patients with rectal cancer, no care changes were implemented for patients with upper abdominal malignancies, such as hepatobiliary or pancreatic cancers. To our surprise, no patients with lung carcinoma in our cohort experienced a COVID-related change in radiation-related care. One explanation for this finding may be that all patients with lung cancer evaluated for RT in the 3 departments during the study period happened to be medically inoperable and were never considered for surgery. Importantly, there are also no available data that could justify delaying radiation for lung cancer, in contrast to other cancer types with better prognoses such as breast and prostate cancer.<sup>28</sup>

We found that patient age and the intent of treatment were predictors of COVID-driven care changes, because older patients and patients undergoing curative treatment showed a significantly higher likelihood of experiencing an alteration in care than younger patients or those undergoing palliative radiation. The positive correlation between age and frequency of care changes in our study may reflect the extra precaution taken with elderly patients given their increased vulnerability to severe COVID illness.<sup>20</sup> According to the National Center for Health Statistics Mortality Reporting System, the frequency of COVID-19 hospitalizations for individuals age >85 years was 513.2 per 100,000 compared with a rate of 136.1 per 100,000 for those age 50 to 64 years.<sup>29</sup> The lower likelihood of COVID-related care changes among patients undergoing palliative RT may be explained by the typically more urgent needs met by palliative RT. Furthermore, radiation oncologists may have considered the risk of exposure to be lower with palliative courses of radiation, which tend to be shorter than most curative radiation regimens.

The main limitation of our study is that a retrospective review may miss changes in patient care that were not explicitly documented by the care team. However, we attempted to partially account for this limitation by enlisting a large team of attending physicians across all 3 departments at the study outset to prospectively build lists of patients whose care was modified as a result of the pandemic. Of note, because the number of cases in

New Jersey started to fall rapidly by the end of May, the choice of June 15, 2020, as the end date for the study may have added a number of patients to our cohort whose care was unaffected by the pandemic, thereby diminishing the proportion of patients recorded as undergoing a COVID-driven care change and potentially underestimating the impact of the pandemic reported in this study.<sup>6</sup> Setting an earlier end date may have magnified the measured frequency of COVID-related care changes, but our chosen end date corresponded with an official date set by the state government to mark the next phase of reopening, signifying a drop in the case rate. The chosen end date also allowed us to capture several patients who elected to delay their radiation consultation beyond the end of May and patients who experienced delays in obtaining insurance coverage during the pandemic.

Previous studies exploring the impact of the COVID-19 pandemic on the delivery of cancer care have thus far primarily been based on patient survey data.<sup>4,13-15</sup> In contrast, by identifying care changes through an objective evaluation of charts, our approach avoids multiple sources of bias that can potentially confound patient survey data, including patient recall and self-selection bias, which may inflate the reported frequency of COVID-related care changes.<sup>30</sup>

## Conclusions

To our knowledge, this is the first multi-institutional study to characterize the impact of the COVID-19 pandemic on the utilization of RT in the hardest-hit region of the United States. Nearly one-fifth of all patients in our study population experienced at least 1 radiation-related care change that was directly attributable to the pandemic. RT delays were the most common change observed, and close to half of all delays were directed by the treating physician. We successfully identified 3 predictors of COVID-related care changes, as older patients, patients treated with curative intent, and patients with rectal cancer showed a significantly higher likelihood of experiencing a change in their RT regimen. By shedding light on the clinical decision making of radiation oncologists at the initial epicenter of the U.S. COVID-19 pandemic, our study offers valuable lessons on how oncologic care can be carefully adapted to ensure adequate protection from a widespread deadly pathogen while maximizing cancer control. We hope this study helps inform the development of treatment guidelines for this and future pandemics.

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