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Radiology Workload Changes During the COVID-19 Pandemic: Implications for Staff Redeployment

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Rationale and Objectives: Quantify changes in total and by-subspecialty radiology workload due to deferring nonurgent services during the initial COVID-19 pandemic, and describe operational strategies implemented due to shifts in priority.

Materials and Methods: This retrospective, Institutional Review Board-exempt, study was performed between February 3, 2020 and April 19, 2020 at a large academic medical center. During March 9–15 (intervention period), nonurgent outpatient service deferrals began. Five-week periods pre- (baseline) and postintervention (COVID) were defined. Primary outcomes were radiology volume (reports per day) overall and in 11 subspecialty divisions. Linear regression assessed relationship between baseline vs. COVID volumes stratified by division. Secondary outcomes included changes in relative value units (RVUs), inpatient and outpatient volumes.

Results: There were 62,791 baseline reports vs. 23,369 during COVID; a 60% overall precipitous volume decrease ($p < 0.001$). Mean volume decrease pre- and during-COVID was significant ($p < 0.001$) amongst all individual divisions. Mean volume decrease differed amongst divisions: Interventional Radiology experienced least disruption (29% volume decrease), 7 divisions experienced 40%–60% decreases, and Musculoskeletal, Breast, and Cardiovascular imaging experienced $>75\%$ volume decrease. Total RVUs decreased 60% (71,186 baseline; 28,476 COVID). Both outpatient and inpatient report volumes decreased; 72% (41,115 baseline; 11,326 COVID) and 43% (12,626 baseline vs. 6,845 COVID), respectively. In labor pool tracking data, 21.8% (162/744) total radiology employees were reassigned to other hospital duties during the intervention period.

Conclusion: Precipitous radiology workload reductions impacted subspecialty divisions with marked variation. Data-driven operational decisions during COVID-19 assisted workflow and staffing assignment changes. Ongoing adjustments will be needed as healthcare systems transition operations to a “new normal.”

Key Words: COVID-19; Reassignment; Staffing; Operations; Volume.

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Abbreviations: **Breast** breast imaging, **CV** cardiovascular imaging, **IR** interventional radiology, **MSK** musculoskeletal imaging, **RVUs** relative value units, **US** ultrasound

INTRODUCTION

The COVID-19 pandemic has profoundly impacted medical centers nationwide as they determined how best to reorganize health resources (1). The first confirmed COVID-19 case in our state was reported February 1, 2020; (reference redacted for blinded peer review) cases increased rapidly in early March. To address predicted increases of COVID-19 patients, our hospital system adopted

a central Hospital Incident Command model (reference redacted) to reorganize and redeploy resources across the system, including ambulatory, research operations, planning, logistics, and finances. Staff, equipment, facilities, and patient care services were reorganized to focus on COVID-19-related activities such as adopting the universal masking policy (2) and creating new COVID-19 wards. Deferring nonurgent outpatient services and elective surgeries was the single most disruptive intervention, also adopted by many hospitals across the country per Centers for Disease Control and Prevention (3), American College of Surgeons (4), and American College of Radiology (5) recommendations. The impact of deferring large numbers of services has yet to manifest but has significant financial implications (6,7).

It is very challenging to gauge a pandemic in real-time and calibrate resources to shifting demands (8). Volume decreases can reduce staff duties, making them available to help in other

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capacities within the department or hospital. However, who should be chosen and how much of the workforce should be kept in reserve in a multiphase plan has not been clearly described in the literature. During the 2003 severe acute respiratory syndrome outbreak, hiring vital personnel was the greatest economic cost; timely staff training was one of the biggest challenges (9). Staff mandated overtime and duty reassignment are important local resources that may be necessary depending on severity of the crisis (10).

We anticipated that during the COVID-19 pandemic: (1) a subset of radiology volumes related to emergency, critical care, and thoracic imaging would increase, given that chest radiographs were part of the triage algorithm for COVID-19 patients (11), and (2) volumes for other radiology divisions would decrease due to deferring nonurgent services. Decreases in radiology volume from baseline could identify opportunities for staff reassignment to other care areas. Further, when standard hospital operations are ready to resume, data gathered from baseline performance and during the COVID-19 surge may help predict increased volume for which various radiology divisions within a department should prepare. Therefore, this study aimed to quantify changes in total and by-subspecialty radiology workload due to deferring nonurgent services during the initial COVID-19 pandemic, and describe operational strategies implemented due to shifts in priority.

MATERIALS AND METHODS

Study Setting and Design

This HIPAA-compliant, Institutional Review Board-exempt, retrospective study was performed at an urban academic medical center at a health care system with a 793-bed quaternary care hospital. The subspecialty-focused Radiology Department is responsible for radiologic studies conducted within the academic medical center, community hospital, outpatient cancer center, and outpatient imaging centers. Eleven subspecialty divisions include abdominal imaging, interventional radiology (IR), breast imaging (Breast), oncologic imaging, Emergency Department imaging, musculoskeletal imaging (MSK), cardiovascular imaging (CV), neuroradiology, nuclear medicine, thoracic imaging, and ultrasound (US).

Intervention and Study Time Periods

The hospital officially announced the policy to defer nonurgent outpatient services and elective surgeries, the primary intervention, on Friday, March 13, 2020. In addition, the Governor had declared a state of emergency on March 10, followed by state-wide closure of public schools on March 13. A cohort of ~60 employees of 1 large firm had been sent to our institution for COVID-19 testing on Friday, March 6. Possibly because of subsequent press coverage of this cohort as well as new state-wide policies, we observed that patients

began cancelling or no-showing for scheduled appointments on Monday, March 9. Hospital central command determined hospital policies taking into account local and state mandates including work-from-home guidelines, universal masking, limits on group gatherings, and deferring lower urgency exams. Imaging devices and sites were closed except for a limited number of relatively isolated outpatient imaging sites kept open to provide outpatient imaging when clinically needed, at the discretion of ordering providers, while maintaining social distancing requirements. Starting March 13 and continuing through the weekend of March 14 and 15, the department initiated the rescheduling of all screening exams such as screening mammography, CT colonography, lung cancer screening, bone density, and cardiac calcium scoring. Division chiefs assigned subspecialty radiologists to perform triaging (assignment of priority scores) for scheduled outpatient imaging. Department leadership developed a strategy to close 7 of 15 outpatient MRI scanners, 3 of 8 outpatient CT scanners, 3 of 4 community breast centers, and all nuclear medicine exercise stress test scanners; this was implemented the following week as volume decreased further due to clinics deferring patient appointments.

Concurrent with the deferral of elective care across all departments, the hospital developed a Labor Pool to reassign staff (including from Radiology) to areas of clinical need, including direct patient care. Other reassignments included distribution of personal protective equipment, checking daily staff health attestations, interpreter services, and monitoring nursing and physician doffing/donning of personal protective equipment on COVID-19 wards. All radiologist reassignments were voluntary, and no one was mandated or refused to redeploy. All non-MD reassignments were mandated by hospital policy and adjusted for employees at high risk or who lived at home with individuals at high risk (e.g., pregnancy or immunosuppression) as assessed by our institution's employee health services. If an employee was not willing to be redeployed, that individual's benefit time would be used otherwise they would be unpaid. Hazard pay was not granted due to hospital policy; however, when the department did not have enough work for employees either in their actual roles or for redeployment, they were paid even while staying at home. No employees were fired or furloughed.

Given the constellation of events surrounding our announcement regarding nonurgent services, we set the week of March 9–15, 2020 as the study intervention period. We defined the 5-week period between February 3 and March 8, 2020 as the baseline “pre-COVID” period, and the 5-weeks from March 16 to April 19, 2020 as the “during-COVID” period.

Data Collection

During the study period, daily productivity metrics including total numbers of radiology reports by setting (inpatient, outpatient, and Emergency Department), and associated work relative value units (RVUs) were tracked by subspecialty

division using a pre-existing quality and safety dashboard (references redacted). These data were subsequently downloaded to Microsoft Excel (2020, Microsoft Corporation, Redmond, WA). A report was counted after it was signed by the attending physician and tallied by its date of service. Associated work RVUs were tallied after charge posting. Staff reassignment was tracked via the Labor Pool and the Radiology Quality/Safety Officer.

Primary and Secondary Outcome Measures

The primary outcome measure was the change in radiology report volume, measured as the pre- vs. postintervention difference in number of radiology reports from CT, MR, US, radiographs, IR, and nuclear medicine examinations. Procedures performed by physician assistants were excluded. We assessed volume change overall and at the divisional level for each of the 11 subspecialty divisions.

Secondary outcomes were the RVUs associated with the radiology reports, the percentage change in inpatient and outpatient radiology volume, and the mean number of outpatient reports per weekday at baseline compared to during-COVID. Redeployment volunteering and reassignment was coordinated with the hospital labor pool and with Radiology senior leadership.

Statistical Analysis

The overall and by-division volume of reports during the study period, pre- and during-COVID, were presented using descriptive statistics. The percentage of outpatient studies at baseline and percent change in volume was presented overall and stratified by division. Ordinary linear regression with Newey-West standard errors was used to determine the change in daily mean report volume between baseline and during-COVID stages overall and stratified by division while accounting for potential autocorrelation. Similarly, linear regression was used to determine if the change in report

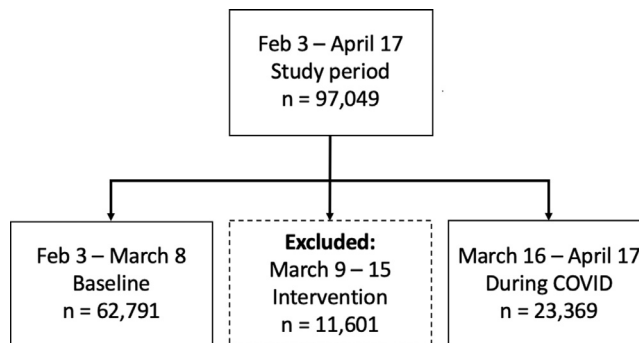


Figure 1. Flow diagram of methodology.

volumes was different between outpatient and inpatient reports through the use of an interaction term. Statistical significance overall and for each division was assessed using a Wald test on estimated regression coefficients with corresponding Wald 95% confidence intervals. All testing was 2-tailed and *p* values less than 0.05 were considered statistically significant. Statistical analysis was performed using R statistical programming language (version 4.0.0; The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Radiology Report Volumes

A total of 62,791 reports were performed by the Radiology Department in the baseline period versus 23,369 reports in the COVID period (Fig 1), a 60% overall decrease in volume. Changes in radiology report volume by division are depicted in Table 1. Strong evidence was found that the mean daily volume of reports decreased substantially after the COVID-19 intervention in the overall department ($\beta = -102.4$; 95% CI $-126.9, -77.9$; $p < 0.001$) as well as individual divisions (see Table 1). Compared to baseline, COVID volume decreased in all 11 divisions. One division, IR, experienced a

TABLE 1. Change in Radiology Report Volume by Division and Total, Baseline vs. COVID Periods

Division	Total Volume Baseline	Total Volume During COVID	% Change in Volume	Mean Decrease in Daily Volume (β)	95% Confidence Interval	% Outpatient Volume at Baseline
Thoracic	11,194	5303	-55.1	-168.3*	-208.4, -128.2	52.6
Musculoskeletal	9360	1130	-88.2	-235.1*	-302.4, -167.9	96.0
Emergency	9162	4668	-51.8	-128.4*	-145.5, -111.3	-
Breast	7582	1013	-87.0	-187.7*	-254.3, -121.1	99.6
Abdominal	6939	2896	-59.3	-115.5*	-165.9, -65.1	67.0
Neuroradiology	6350	2584	-61.4	-107.6*	-147.8, -67.4	68.6
Ultrasound	5426	2488	-54.5	-83.9*	-113.9, -53.9	91.2
Oncology	2737	1592	-39.1	-32.7*	-48.4, -17.1	97.5
Nuclear Medicine	2188	985	-55.4	-34.4*	-46.2, -22.5	88.6
Cardiovascular	1211	247	-80.4	-27.5*	-33.1, -22.0	77.8
Interventional Radiology	642	463	-28.9	-5.1*	-9.6, -0.6	66.0
Total	62,791	23,369	-60.1	-102.4*	-126.9, -77.9	66.3

* Indicates statistical significance, all $p < 0.001$.

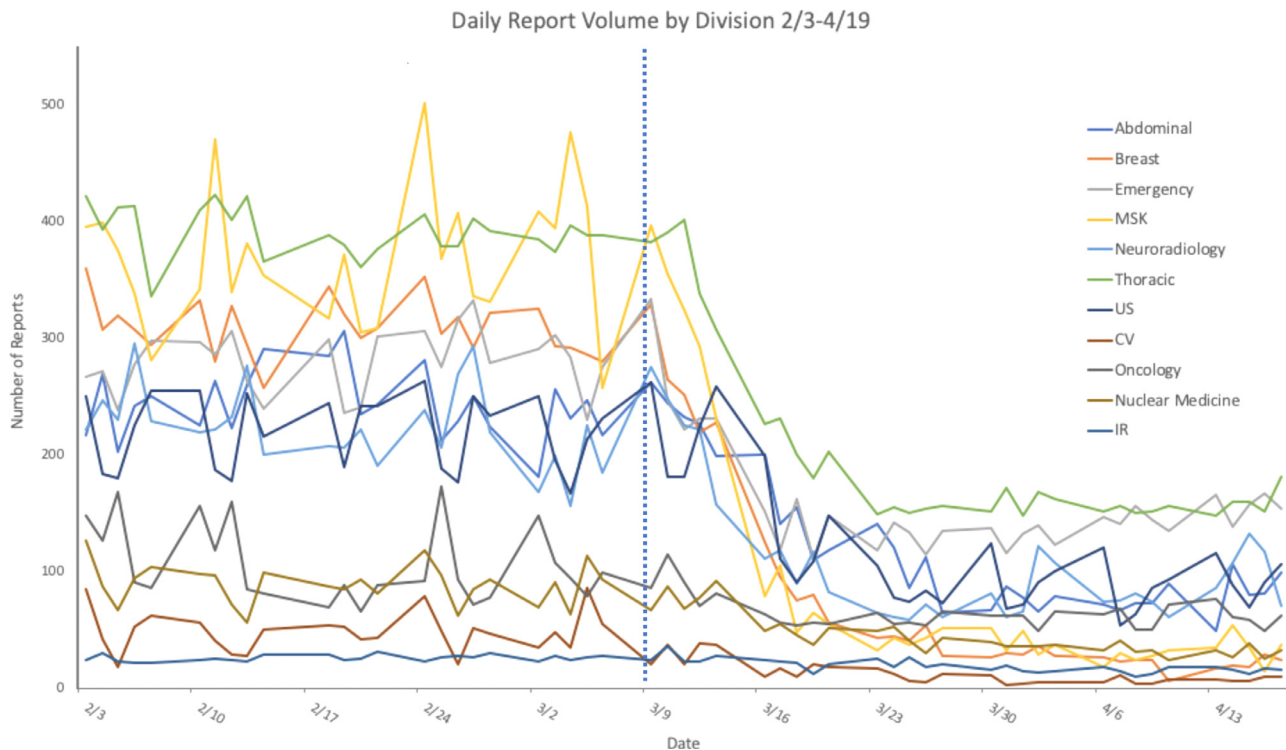


Figure 2. Daily Report Volume by Radiology Division February 3–April 19, 2020. (Color version of figure is available online.)

volume decrease of 29%, whereas seven divisions experienced 40%–60% decrease in volume, and three divisions (MSK, Breast, and CV) experienced greater than 75% decreases in volume.

Workday report volumes by division between February 3 and April 19, 2020 are depicted in Figure 2. Daily divisional workloads started decreasing sharply during the week of March 9–March 15, 2020 and continued through the end of March. Although all divisions were affected, divisional volume did not drop at the same rate.

Secondary Outcomes

Total department work RVUs decreased 60% in the COVID period (28,476) compared to baseline (71,186), a net difference of 42,710 RVUs.

Both outpatient and inpatient report volumes decreased, by 72% (41,115 baseline vs. 11,326 COVID) and 43% (12,626 baseline vs. 6,845 COVID), respectively. However, outpatient report volumes decreased significantly more than inpatient volumes ($p < 0.001$). Divisions varied at baseline in the proportion of their volume that was outpatient. Divisions with greater than 75% outpatient volume at baseline included Breast (99.6%), oncologic imaging (97.5%), MSK (96.0%), US (91.2%), nuclear medicine (88.6%), and CV (77.8%). Mean weekday outpatient volume was 1,908 reports per day at baseline, compared to approximately 591 daily reports during COVID.

Labor pool tracking showed that a 24.9% (145/583) of radiology employees were reassigned roles outside their usual

job description during the intervention period, including staff physicians, trainees, technologists and practice assistants. Table 2 outlines various redeployment tasks, both volunteer and mandatory reassignments by the labor pool.

DISCUSSION

In this assessment of initial effects of the COVID-19 pandemic on radiology department workload, overall report volume and associated RVUs decreased in the 5-weeks after deferments of non-urgent outpatient services and surgeries began, compared to the 5-weeks prior to initiating deferments, by 60% ($p < 0.001$). As expected, work RVUs also decreased by 60%. Mean daily change in reports decreased significantly for all divisions ($p < 0.001$). Outpatient report volumes decreased significantly more than inpatient volumes ($p < 0.001$).

Our findings are consistent with anecdotal estimates (6) and March 2020 patient financial transaction data (12). We had anticipated volumes in emergency radiology and thoracic imaging would increase due to growing numbers of COVID-19 patients requiring emergency, inpatient, and critical care. However, the majority of COVID-19 cases were diagnosed and treated without imaging. CT was largely reserved for evaluation of complications of COVID-19 pneumonia or for assessment if alternative diagnoses were suspected. The drop from baseline imaging far exceeded the new cohort of COVID-19 patients who required imaging during the postintervention period. Moreover, due to additional systemic effects of COVID and ongoing care for

TABLE 2. Redeployment timeline of staff members during COVID

Start Date	Redeployment Task	Staff Members	Number Who Volunteered/Redeployed
March 23	Request from radiology leadership by email for faculty volunteers from other subspecialty divisions to work in Thoracic and Emergency Department (ED) radiology divisions as needed	Faculty ¹	17/0
March 28	Employee health attestation and PPE distribution at hospital entrances	Faculty, ^{1,2} trainees, ¹ technical managers, ¹ technical staff, ³ administrative staff ³	19/19 faculty, 11/11 residents, 10/10 technical/admin volunteers, 162/583 administrative/technical staff reassigned
March 29	Survey via email to faculty and trainees for those with prior experience as: (1) ED responding physician; (2) General Medicine Attending physician; (3) Medical ICU attending	Faculty, ¹ trainees ¹	14/0
March 30	COVID testing tent	Technical staff ³	3/3
April 1	Virtual radiology consultants on rounds	Trainees	4/4
April 3	COVID field hospital ⁶	Chair of Radiology, Safety Officer, technical staff	23/23
April 7	Survey via email requesting past electronic health record (Epic) experience on medical/surgical service, encompassing familiarity with note taking, test ordering for Virtual Scribe role	Faculty, trainees	43/4
April 9	Virtual Scribes for COVID medical team rounds	Faculty ⁴	4/4
April 13	Working as medical staff on COVID floors	Trainees ^{1,5}	21/4*
April 17	Donning/doffing monitors on COVID floors	Faculty, ^{1,2} trainees, ¹ technical staff ³	8/8*
April 17	Spanish interpreters	Faculty and trainees	3/1*

* Assigned in April, redeployed in May/June 2020.

¹ Indicates volunteer.

² Indicates senior leadership faculty.

³ Indicates reassignment by labor pool.

⁴ Two Breast and two Musculoskeletal Radiology faculty.

⁵ Faculty, residents, and fellows volunteered but the Department of Medicine selected residents due to their more recent clinical practice in Internal Medicine.

⁶ X-ray technologists rotated, and the Chair and Quality Safety Officer were located full-time at a field hospital.

non-COVID patients, a broader range of radiology services were needed than just thoracic imaging, from interventional to cancer and obstetrical imaging.

Not all divisions experienced the same degree of volume loss. Divisions that consisted of a greater proportion of outpatient imaging prepandemic experienced greater decreases (e.g., MSK, Breast, and CV). Notable exceptions included oncologic imaging which consisted of 97.5% outpatient reports at baseline with overall decrease in volume by 41.8%. This was likely due to cancer patients requiring ongoing outpatient imaging, such as restaging and post-treatment scans (13). It is possible that lesser reductions in volume observed in US, nuclear medicine, and IR was due to ongoing imaging needs in a subset of the population. For example, PET-CT restaging scans for oncology patients continued in order to avoid delaying diagnosis and treatment. Additionally, our department does a high volume of obstetrical US, which continued during the pandemic.

Staffing needs of radiology divisions decreased substantially during COVID due to low volumes of imaging. In contrast,

hospital-wide clinical needs increased during the pandemic surge. The public health crisis required our institution to organize and work in new ways to accommodate many rapid changes (14). During previous severe acute respiratory syndrome outbreaks, hospitals found that utilization of local resources such as reassigning staff, including radiologists, was an important crisis management strategy (9). Roles that are not within traditional skillsets of radiology staff include personal protective equipment distribution, donning and doffing safety officer, virtual scribes, and language translators (Table 2). Education and re-training occurred in specific groups based on the redeployment task. For example, the trainees who prepared to be responding clinicians on COVID wards received virtual training from the Medicine team currently performing those roles. Our department employees participated in a variety of redeployment roles although staff availability depended on radiology work volumes. Employees of all ages volunteered for various tasks. However, for some tasks such as responding clinician, year of experience in radiology did play a role in redeployment strategies and trainees

were preferred by the Department of Medicine because they had more recent clinical medical experience than more senior radiologists. A data-driven approach showing the impact of the pandemic allowed for better mapping of valuable staff resources to hospital needs; for instance, staff predominantly working in ambulatory, outpatient settings (e.g., breast imaging, orthopedic imaging) would be more available than other staff (e.g., IR, inpatient x-ray) for redeployment in the event of a repeat surge of COVID.

Overall, the strategies that worked well included central decision-making by the hospital incident command structure, tabling previous non-COVID-related projects, and focusing on the contemporaneous COVID-19-related issues by every level of management. Communication tools such as online platforms assisted rapid changes and communication between teams while assisting social distancing requirements in the department. Scanner units were reconfigured so that there were dedicated COVID areas for patients who needed CT, MRI, and image-guided procedures. Social distancing included remote workstations around the hospital and virtual desktops to allow primary interpretation and readouts from home. No employees tested positive for COVID-19 linked to work-related exposure.

Deferring nonurgent outpatient services and surgeries will substantially impact hospital finances as income earned by delivering patient services is normally the primary way that hospitals generate revenue. The proportion of outpatient services that have dropped per division is also a window into decreased activity of referral services such as neurosurgery, orthopedics, and cardiology. During the recovery phase, return of outpatient volumes will depend on resumption of patient services in a variety of subspecialties. However, as experienced in the 2003 severe acute respiratory syndrome outbreak, hospital departments may recover at different rates (15).

Limitations of the study include its design as a single institution study. Since different cities experienced the COVID-19 pandemic differently (16,17), generalizability of our study at a single academic institution is unclear. In addition, multiple factors during the intervention period may have impacted imaging volumes, including national and statewide events as well as interventions at the hospital; furthermore, departmental strategies including closing scanners were not completely implemented prior to March 15, 2020 and ramping down of operations continued for several weeks. In addition, the study covers a relatively short period of time (<3 months) which only accounted for a portion of all the workload changes and staff reassignments due to COVID-19 which continued until June 2020. Different referring departments in our hospital were affected to different degrees; for instance, non-COVID-related medical and general surgical care continued to a larger degree than orthopedic or neurologic care. Differences in the deferral of non-COVID care among referring departments would variably affect radiology volumes, but an analysis of factors affecting other departments is beyond the scope of this manuscript.

By monitoring empiric data during the COVID-19 crisis, we have implemented departmental strategies to transform our institution into a COVID-hospital. Furthermore, these findings can help direct strategic planning during the ramp-up and recovery period as the hospital will likely need to maintain capacity for COVID-19 patients as well as resume normal operations including addressing deferred outpatient elective care.

CONCLUSION

Deferring nonurgent outpatient procedures and surgeries resulted in decreased radiology volumes, overall and by-sub-specialty division, during the initial stage of the COVID-19 pandemic. Divisional workload decreases varied substantially, with some divisions losing nearly their entire baseline volume whereas others experienced milder disruptions. The most impacted divisions at our institution were musculoskeletal, breast, and CV, most likely due to the large component of outpatient volume; IR was least impacted, likely because many procedural cases could not be deferred due to patient care needs. Both the number of inpatient and outpatient examinations dropped, although outpatient volume decreased significantly more than inpatient volume. Due to shifts in priority to focus on COVID-19 patient care at the hospital level, operational strategies were implemented at hospital- and departmental-levels to reallocate local resources in preparation for both the surge and recovery stages, including staff reassignment. Our study suggests ways in which strengths of the available workforce may be used to optimize patient care and informs next steps as the current crisis unfolds.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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